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CROP TAXONOMY.

CROP TAXONOMY is that division of applied botany which is concerned with the classification of the numerous species and varieties of plants cultivated for their economic value. The definition may suggest a dry subject of little practical importance, but in fact the study can be of absorbing interest and is fundamental to all those other divisions of botany that are more directly responsible for crop improvement.

Plant breeding, with all its powers of increasing the productiveness of crops, depends on taxonomy for its rational direction, and it is significant that some of the best work of recent years in the taxonomic field has been done by geneticists and plant breeders, who are in the best of positions to see its economic value. Success in plant breeding depends on the bringing together of different varieties, sometimes of different species, or even genera, in order that their several good qualities may be combined in better proportions. The wider the collections the breeder has at his command the better his chances of adapting his new types to the conditions for which they are required, and the less the risk that his efforts may be wasted in a laborious synthesis of a type that already exists, unknown to him.

Collection depends in its turn on survey, and records of distribution, which may be included for practical purposes under the heading of taxonomy. It also involves close and careful comparison of varieties if it is to be done economically. Numerous as are the varieties themselves, their names are more numerous still, and the importance to be attached to a name varies widely from crop to crop and from country to country. Expense may be incurred in introducing, perhaps from the other side of the world, a "new variety", only to prove on its arrival that there is nothing new about it except its name. Less frequently, perhaps, but no less disastrously, distinct varieties in different countries pass under the same name, and attempts made in one place to apply experience gained in the other lead to costly failures. Either of these too common accidents demonstrates clearly the economic value of systematic studies.

In the eighteenth and nineteenth centuries the main centres of tropical agricultural research were the various botanic gardens, and whatever their agricultural limitations in other directions, they were strong on the systematic side of their work. It may be that in the twentieth century the new

and exciting possibilities opened up by genetics and cytology have led us somewhat astray from the more prosaic path of taxonomy. It is to be remembered, however, that the period has been one of tremendous development, and that botanical staffs have not been increased in proportion to the rising flood of systematic work that is waiting to be done. Increasing facilities of communication have stimulated the exchange both of material and of information faster than either could be properly assimilated. Concurrently in the earlier years of the century, expanding consumption stimulated production at a rate out of all proportion to the meagre provision made for research. As one result, vast new areas have been planted with relatively inefficient material, and since the lag of consumption behind expanding production began to sharpen competition, the efficiency of the plant material available in any country has tended more and more to be a decisive factor in agricultural profits.

Thus in more than one direction tropical agriculture has outrun the botanical knowledge on which it ultimately depends, and in some quarters, though not yet as widely as it should be, that fact is being recognised. It was recognised by the Conference of Colonial Directors of Agriculture in 1931, and led to a recommendation that Kew should be asked, in co-operation with Colonial Departments of Agriculture, to furnish information regarding the availability of plants and seed material with a view to facilitating their introduction into other parts of the Empire.

As a result there has now appeared " Cultivated Crop Plants of the British Empire and the Anglo-Egyptian Sudan (Tropical and Sub-Tropical) " (Royal Botanic Gardens, Kew, Bulletin of Miscellaneous Information, Additional Series, No. XII, *His Majesty's Stationery Office*, 1936. Price 6*s*. 6*d*. net). As explained by Sir Arthur Hill in a foreword, this is the first attempt that has been made to furnish information showing the distribution of tropical and sub-tropical crop plants in the British Empire, and its compilation has been undertaken in the belief that it will prove of value, especially to the officers of the several Departments of Agriculture concerned. It is hoped that it may stimulate the trial of new crops, and more especially the trial of other varieties of crops already under cultivation.

The publication consists of two parts, an alphabetical list of crop plants occupying 180 pages, and crop notes accounting for another 60 pages. The list has been compiled by Mr. H. C. Sampson from the replies to a questionnaire circulated to all the Departments concerned. It is thus a notable example of Imperial co-operation, especially encouraging for the fact that it is certain to stimulate further co-operative effort along similar lines. The work of the compiler has been heavy, since the information has been arranged for maximum usefulness. In the first place, every effort has been made to ascertain the correct name by which the species cited should be known, and as all botanists know, the determination of correct nomenclature in crops is often a tedious business. With the authority of the Royal Botanic Gardens behind it, this list will no doubt help very much to standardise the use of correct scientific names for economic plants in British countries, and that will not be the least of its uses. Due attention is given to common synonyms, to which an index is provided as an appendix.

The countries where the crop is now being grown, or has been tried, are entered under five headings (*a*) those where it is indigenous or an early introduction (*b*) those where it is more recent, but has been successfully introduced, in the sense that it has got beyond the experimental stage of cultivation (*c*) those where it is still under trial or established on an acclimatisation station (*d*) those where it has been successfully introduced but cultivation has subsequently disappeared or been abandoned (*e*) those where it has been introduced and failed to become established.

The crop notes are especially intended to be of use to those engaged in studying and comparing varieties. The number of crops so dealt with is necessarily limited, and those selected are in the main the staple foods of the indigenous peoples. Here the general range of variability within the crop is indicated, and the characters most useful in classification are described. These notes serve to indicate the features that should be mentioned in descriptions, and in the present state of knowledge fuller and better descriptions of our crop varieties are urgently needed as a preliminary to the international codification that is the botanist's ideal.

E. E. C.

LOW TEMPERATURE RESEARCH STATION.

The future of this Station (which had been in doubt for some time) has now been satisfactorily settled. The Secretary of State for the Colonies has informed the Governing Body of the College that the Colonial Development Advisory Committee has recommended a capital grant to cover the cost of extending the present building and effecting certain necessary repairs and alterations and a further free grant to meet the recurrent expenditure of the Station for the period 1st October, 1936, to 30th September, 1941. In making this recommendation the Committee expressed the hope that every endeavour will be made to secure contributions

from other sources so as to make possible a reduction in the grant from the Colonial Development Fund. The Lords Commissioners of His Majesty's Treasury have now indicated their approval of the issue of these grants.

Negotiations undertaken in connexion with this Station have been proceeding for a considerable time. The fact that they have now terminated so happily is a recognition of the valuable work that has emerged since investigations were first begun.

The Low Temperature Research Station was designed and constructed eight years ago to deal with the storage problems of one crop only, namely, bananas. Since then the scope of the work has been extended to include other tropical fruits and vegetables, many of these involving the use of temperatures considerably lower than those for the banana. During the last eight years also low temperature research has made striking advances in many directions and it will, therefore, be necessary to recondition and bring up-to-date the existing Station. The funds now available will enable the necessary alterations to be carried out and it will be possible to run the plant at full capacity for the next five years.

G.E.

THE STORAGE OF WEST INDIAN MANGOES.*

In the introduction to this Memoir, the third of a series issued by the Low Temperature Research Station, Trinidad, the authors state:

"The need for precise information on the behaviour of mango varieties in cold storage has become increasingly evident during the past few years. Not only have efforts been made to effect the shipment of this fruit from Bombay to English markets, but in the West Indies the rapid increase in acreage of selected, grafted varieties has made it imperative that outlets should be sought for this commodity. To this end carefully controlled storage trials have become necessary. In particular our attention has been directed to three varieties, the Julie which crops abundantly under conditions such as prevail in Trinidad and St. Lucia, the Peter's or Bombay which is regarded as the best export type produced in Jamaica, and the Ceylon No. 1 which yields a good class of fruit in Grenada and Dominica.

In the past various small shipments have been made both by private individuals and others interested commercially. The cumulative experience indicates that the outlook for this crop is promising provided markets can be developed. In anticipating the possible expansion of the mango industry certain marketing aspects should be carefully considered at this point because of the relation they bear to transport and refrigeration problems. Both in Canada and Great Britain the mango is still a connoisseur's fruit, sold in limited quantities at high prices. Where only small consignments are involved, transport facilities tend to be variable and, on the whole, inadequate, with concomitant high wastage; only where special arrangements have been made for distribution can the high prices be maintained; delay during retailing usually involves a marked reduction in profit because of over-ripeness and the onset of wastage. In brief, West Indian experience of this crop is based on small consignments only, handled under unstandardised and frequently unsatisfactory conditions of transport. This situation seems likely to persist until the industry is expanded to a point where it will be profitable to shipping companies to provide refrigerated hold-space adequately controlled in relation to ascertained storage requirements. It is now evident that the production of mangoes in the West Indies, and presumably in other tropical regions also, is capable of almost indefinite extension. Furthermore, although there is admittedly serious competition to be encountered during the summer months from home-grown (temperate) soft fruits, there is no reason why the best types of mango should not be familiarised on new markets as have other tropical fruits in the past.

The mango is a delicate fruit and careful observation of certain conditions is essential to its successful overseas transport. Quite apart from the fact that small consignments can be of little financial interest to shipping companies, it should be pointed out that they bring their own difficulties in respect of refrigerated stowage. In illustration of this it may be mentioned that in a well-stacked, fully-charged commercial hold or refrigerated store, temperature and humidity can be more nearly stabilised at the required values than if only small lots of fruit are present. Such stabilisation of storage conditions is particularly important in handling tropical produce where the fruit has to be picked somewhat immature in relation to a transport period of 10-15-20 days followed by a further distribution period of 5 to 10 days. It is evident that satisfactory results will only be consistently obtained when the industry is sufficiently extensive to supply standardised consignments of a magnitude to secure adequate shipping facilities. This consideration stands in close relation to the potential expansion of this and other industries in the West Indies."

* Wardlaw, C. W. and Leonard, E. R.—The Storage of West Indian Mangoes, Memoir No. 3, Low Temperature Research Station, Trinidad, pp. 47 and 12 figs. Copies (price 2s.) may be obtained on application to the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

After reviewing previous literature on mango storage the authors discuss various aspects of handling the fruit during refrigeration and the changes occurring during its development and ripening. In addition, the problems of anthracnose, chilling, loss in weight during storage and fungal wastage are examined. This is followed by a detailed account of storage trials on Julie, Peter's and Ceylon No. 1 mangoes, and other varieties.

The authors' conclusions and recommendations are as follows :—

" 1. *Maturity on Picking.*

Experience has shown that mangoes, over a considerable range of maturity, will eventually ripen if maintained under suitable conditions. For convenience, in the Julie variety, three stages may be defined : (*a*) almost full-grown, green fruits in which the shoulders are level with the insertion of the stem-end ; (*b*) a later stage where further growth has taken place, so that the shoulders are raised above the hollow in which the stem-end is inserted ; (*c*) in this stage little or no further growth has taken place, but fruits are on the point of becoming soft.

The selection of fruits of different maturities is dependent on (i) the duration and temperature of transport and (ii) the presence or absence of cold storage facilities during the distribution period. Where cold storage facilities are available until the day fruit passes into the hands of the consumer, the best results were obtained when fruit of category (*c*) (*i.e.*, picked just prior to softening) was maintained throughout at a temperature of 45°F. ; the full flavour was thus obtained and wastage was at a minimum. It is to be noted that this class of fruit was not subject to chilling. Where such facilities are not available, and where a total storage life of 20 to 25 days is envisaged, fruit should be picked at a stage of maturity intermediate between grades (*a*) and (*b*) the bias being towards the more mature grade (*b*) ; the appropriate storage and ripening temperatures are discussed below.

The maturity criteria afforded by the relative positions of stem-end insertion and shoulder development appear to be well-established for the Julie variety ; Cheema and Dani have demonstrated that they are also applicable to the Alphonso variety exported from India.

In the Ceylon No. 1 variety, fruits should be picked full-grown with the first trace of colour ; as this is a clear-skinned variety, little difficulty should be experienced in effecting the selection of a commercial grade of fruit.

With the Peter's (Bombay) variety, the question of picking maturity requires further elucidation. As Trinidad fruit is apparently somewhat atypical and is unlikely to prove of commercial importance, this problem is a matter for local consideration in those islands where a superior class of fruit is produced.

According to the duration of storage, *i.e.*, for the Canadian as against the English market, suitable adjustments of picking maturity between grades (*a*) and (*b*) should be made.

2. *Packing.*

The standard 20-lb. tomato lug (5 inches by 16½ inches by 17 inches), packed in one or two layers, as suggested in the Fruit and Vegetable Council Report, would appear to be suitable for mangoes. Should a change in pack be contemplated, a single layer appears preferable.

In view of the considerable shrivelling to which varieties such as the Julie are subject, wrapping papers should be selected from among those known to have good moisture-retaining properties. The fruits, 25 to 40 per crate, according to size, should be safe-guarded from bruising against the slats and sides by the insertion of a light pad of wood-wool. To avoid undue self-heating in packs and the danger of accelerated ripening on removal from cold storage, the amount of wood-wool used should be reduced to the minimum.

3. *Storage Temperature.*

It has been conclusively demonstrated that mangoes are subject to low temperature injury. Chilling may be manifested in several ways, including the production of definite skin blemishes, failure to develop normal colour on ripening, failure to ripen on removal from cold storage, and a notable decline in resistance to the inroads of pathogens. Susceptibility to chilling varies with variety, maturity on picking, seasons, and duration of exposure to low temperatures. Trinidad experience indicates that mango varieties in general are subject to chilling injury if exposed to temperatures below 48° to 50°F., superficial blemishing being accentuated by partial desiccation, especially where fruits are fully exposed to the action of an air-blast refrigeration. In normal commercial consignments where carefully wrapped and packed fruits are stored in bulk, a transport temperature of 48°F. (with delivery air not falling below that temperature) might be adopted where fruit of approximately grade (*b*) has to be held in cold storage during a voyage of 15 to 20 days. Only where fruit picked on the point of softening, grade (*c*), is being handled should a lower storage temperature, 45°F. as already discussed, be used. It is possible that the storage temperature of 48°F. suggested may require modification in the light of further experience, since, admittedly, it borders on the critical temperature for chilling. It is suggested, in preference to a storage temperature of 50°F., for the following reasons :

(i) to offset the effect of ripening during pre-storage delays ;

(ii) to allow for possible slow rates of cooling and self-heating in bulk consignments ;

(iii) because experimental fruit, held for upwards of 15 to 20 days at 50°F., has been characterised by severe wastage, this temperature being sufficiently high to permit of considerable activity by storage pathogens.

Where only slight chilling has taken place, the effect is largely superficial and not infrequently disappears or is masked by the development of ripening colour.

On removal from cold storage to a temperature of 65° to 70°F., fruits which have not been chilled ripen normally in the course of 4 to 7 days.

The recommendations outlined are in relation to the rather unsatisfactory current shipping facilities. From the data submitted in Part II,* it is evident that more expeditious overseas transport would permit of the shipment of a good class of fruit at temperatures between 50°F. and 60°F.

4. *Control of Wastage.*

The wastage problem in mango storage is serious. Quite apart from damage due to wound parasites (which in our experience has been inconsiderable in carefully-handled fruit) the majority of fruits for storage, though apparently sound and unblemished, carry latent infections of several important pathogens. The data set out in this memoir show clearly that disease incidence, attributable to such dormant infections, is greatly accentuated by chilling, prolonged cold storage, slow ripening and tardy distribution. Except in favourable instances, it seems unlikely that in the class of fruit produced under Trinidad conditions, the total commercial wastage can be curtailed to the customary 10 per cent. allowed for other fruits.

* *See* Memoir.

As rotting is almost entirely due to pathogens established as latent infections during growth, the extent to which wastage may be reduced by spraying operations requires careful investigation. Various experiments undertaken by Banerjee, Karmarkar and Row on the efficacy of steeping fruit in disinfectant solutions such as potassium permanganate, formalin, phenol, &c., prior to packing were attended with negative results—a conclusion in keeping with Trinidad experience with other fruits. It is not impossible that a fuller exploration of this aspect may be attended with more favourable results.

The high incidence of field infections directs attention to the need for careful consideration of orchard sanitation : questions of spacing, pruning, spraying and upkeep generally should be made subjects of special study at this time, while the industry is still in its infancy ; otherwise the high wastage, which will inevitably be experienced later when orchards are in full production, may prove a serious hindrance to successful marketing."

The Memoir throws new light on a number of problems connected with mango storage and should be of particular value to those interested commercially in this fruit. A good deal of scientific data has also been collected which should prove helpful to those engaged in similar problems in other parts of the world. The literature on mango storage is scanty, and on this account the present contribution will no doubt be welcome.

IODINE AND THE CONTROL OF FUNGAL WASTAGE.

By C. W. Wardlaw,

(*Low Temperature Station, Imperial College of Tropical Agriculture, Trinidad, B.W.I.*).

The use of iodised wraps in the prevention of fruit-rotting in storage, advocated by Tomkins (1, 2) both on direct mycological evidence and empirical tests with different fruits, is of considerable practical value and has received wide publicity. That iodine vapour restricts fungal activity is not in question. Nevertheless, the results of a comprehensive series of experiments in Trinidad, using large samples of fruit, indicate that certain precautions should be taken before the use of iodised wraps is advised. An example will make the position clear. With Trinidad grapefruit, a period of at least four to five days elapses between picking and packing ; the effect of iodised wraps on fruit at this stage is not to curtail but actually to promote wastage.

This result and others, which have been substantiated beyond dispute, were so much at variance with Tomkins' finding that a closer examination of the phenomena involved was undertaken, a full account of which will be published later. The points of scientific interest may be briefly mentioned here. The iodine vapour, slowly released from the fruit wraps, is seen to exercise two definite and distinct effects : one is a restrictive effect on the activity of superficial spores and hyphae ; the other, a harmful action on the plant tissue making for a decrease in resistance to invading organisms.

The accumulated evidence shows that where fungal pathogens are still superficial or on the point of becoming established, iodised wraps may be used with advantage, but where the fungus has gained access to the tissues, or is already present as a latent infection, the disorganising effect of iodine on the tissue (with concomitant loss of resistance) may result in a marked increase in wastage. In other words, the delay in applying wraps, together with other circumstances involved in the penetration of a particular organism, determine whether rotting will be controlled or promoted.

In conclusion, while certain types of rotting can undoubtedly be controlled by the use of iodised wraps or iodine under experimental conditions, the greatest caution must be exercised before the principle can be applied to fruit handled under commercial conditions. In each instance, the nature of the specific storage fungi involved a knowledge of the course of their pathogenicity, and the effect of iodine on the fruit, must be clearly understood in advance.

References.

(1) Tomkins, R. G.—Iodised Wraps for the Prevention of Rotting of Fruit. *Jour. Pom. Hort. Sci.*, Vol. XII, No. 4, December 1934.

(2) Tomkins, R. G.—The Rotting of Fruit in Storage. *Dept. Sci. & Indus Res.*, Rept. Food Inves. Board, 1934.

ON THE SEEDLESSNESS OF CITRUS FRUITS WITH PARTICULAR REFERENCE TO MARSH GRAPEFRUIT.

By N. Wright.

A.—Introduction.

Close competition and the rigorous standards demanded by the fruit market may be held largely responsible for the anxious attention now being paid by citrus growers to this problem of "seedlessness". So long as the "seedless" fruit receives its premium, the grower and shipper have to make every effort to standardise that characteristic, and ensure that cases marked "seedless fruit", of whatever variety it may be, shall conform strictly to that specification. Unfortunately seedlessness is a character which, like flavour, cannot be tested and graded except by destruction of the fruit. The onus rests on the grower who must first convince himself that his planting material is absolutely uniform, and secondly be constantly on the look-out for fluctuations from one cause or another in the standard quality of the fruit he exports. It is with the object of assisting him to know more about the causes of those fluctuations, with a view to remedying them, that the following notes summarising our knowledge regarding seedlessness in citrus have been written.

The position in Trinidad is probably not much different from that in other countries, but receives urgency from the fact that so many plantations are only now coming into bearing for the first time. The remedy for a high percentage of seeded fruit coming from an orchard must be sought and applied as soon as possible, so as to involve the least expense and trouble for the growers, and to prevent injury to the island's reputation for "quality" fruit.

Without making the necessary observations and experiments under local conditions it would be useless at present to advise on the best methods of eradicating seeded fruit or of preventing future recurrence of the trouble. We have only the experience of growers and scientists in other countries to guide us in tackling the problem for ourselves. That experience is on the whole rather meagre, and is culled from acquaintance with several different varieties of citrus in places often differing widely in their climatic and cultural conditions. Bearing this in mind, this survey of the findings of foreign workers may help us to anticipate the results of our own observations, and to suggest ways and means of deriving from them the maximum benefit.

B.—Seed Formation in Citrus.

It will be well to review briefly the mechanism of fruit development in Citrus species, since there are peculiarities in the behaviour of this group not shared by the majority of other fruit trees.

Structurally, they are all many-seeded—that is to say, the young fruits at the flowering stage contain a large number of ovules or seed rudiments. In what may be termed the simpler or more primitive varieties, most of these ovules develop, provided that they are fertilised by pollen derived either from the same plant (self-pollination) or from another plant (cross-pollination). It is important to distinguish between *pollination*, which is the transference of pollen to the stigma of the flower, and *fertilization*, which only occurs after the pollen tubes have grown down the style from the stigma to the ovules, and entered them If for any reason pollen does not reach the stigma, or having arrived does not grow down to the ovules, not only the ovules themselves but the whole fruit fails to develop. In these primitive varieties, therefore, the fruits if they develop at all contain numerous seeds.

In the more highly developed varieties, failure of seed formation does not prevent fruit development, which is then said to be *parthenocarpic*. In some cases pollination is necessary; in others it is not. Such parthenocarpic varieties are thus potentially "seedless", though the number of seeds actually found in the fruit will depend upon a number of other factors. If both pollen and ovules are viable, and the pollen grows successfully in the stigmas of the same plant, seedless fruits can only result from causes which prevent pollination, such as an absence of pollinating insects. In some cases, however, although both pollen and ovules are viable, self-pollination is not followed by fertilization and pollen from another variety is necessary before seeds are formed (self-sterility). Pollen from certain other varieties may be equally ineffective (cross-sterility), although some varieties will cross readily.

Not infrequently there is formed some degree of structural sterility, involving either the ovules (female sterility) or the pollen (male sterility) or both, which may be partial or complete. Almost complete structural sterility on both sides is found, for example, in the Washington Navel Orange where it has been demonstrated (Webber 12., Ikeda. 4.) that the young ovule seldom reaches maturity, and that no fertile pollen grains are formed. Ikeda notes a similar disintegration of the young ovules in the Satsuma mandarin. Nagai and Tanikawa (5), investigating four varieties of tangerines, all with fertile pollen, found that they produced fully-seeded (16-49 seeds) fruit on cross-pollination, but completely seedless fruit when self-pollinated. This example shows us that some functional defect was present to prevent fertilization when self-pollinated, and that the mere fact of proving the viability of pollen on an artificial culture medium does not presuppose its effectiveness on any stigma. It is obvious that whatever the condition of the pollen, partial female sterility will lead to a reduction in the number of seeds that can be formed, and complete female sterility to complete seedlessness. Male sterility, in the absence of any foreign pollen which may be fertile, will have similar results.

In citrus we have an additional complication arising from the fact that so-called "apogamic" seed may develop without fertilization, though not necessarily pollination as well. The progeny of such seed is identical with the mother plant from which it has been derived by vegetative growth. We may find therefore that the pollen of certain varieties, though it fails to effect fertilization, may by some chemical stimulus produce apogamic seeds. It seems possible that in rare instances (Webber. 12) apogamy may occur without even pollination, but this is as yet a matter of uncertainty. The only sure proof is by emasculation and bagging of the flower. It is unsafe to predict how many seeds in a fruit apogamy might account for, but the probability is that a fully-seeded fruit with—say 60 to 80 seeds—could not be explained in this way.

The "Marsh" variety of grapefruit may be called commercially "seedless". Hume (3) describes it as having "two to six seeds or none". We have to ask ourselves—what is the origin of those few seeds, and what unusual circumstances are present to cause a marked increase in their number? The general consensus of opinion, though at present we have no extensive data to back it, is that Marsh fruit contains either few (say up to 12) or many seeds (say 40 to 80). This rather suggests that the conditions of seed formation are different in the two cases. If the few seeds of a true Marsh are the product of fertilisation, then partial sterility must be postulated. In that case one would expect to find intermediate stages of increasing sterility and corresponding numbers of seeds. If, on the other hand, those seeds were of apogamic origin, then the fully-seeded fruit could be explained as the result of accidental pollination by a fertile tree in the neighbourhood.

C.—The Causes of Fluctuation in the Normal Seed Content.

Putting aside the possibility of fruit becoming seedy as a result of abnormal apogamic seed development, it will be clear from what we have said that a seedless fruit must be at least self-sterile. If such a fruit now develops seed, the cause may be twofold:—either (1) it has been pollinated by a cross-fertile variety, or (2) it has acquired self-fertility through a genetical change in its constitution—mutation or "sport". In examining the rather conflicting evidence on these two theories, it will be as well to bear in mind the possible effect of the environment upon both of them. We have no proof of its influence, but theoretically we would expect environment to play an important part whichever theory is adopted.

(1) Seediness as a Result of Cross-Pollination. What appears to be the most completely seedless citrus variety under all circumstances is the Tahiti lime. Uphof (11) from an examination of the structure of the flower, came to the conclusion that seed production was impossible, even with foreign pollen. The same author finds that self-pollination in the Satsuma is structurally impossible, but does not appear to exclude altogether the chances of successful crossing. Tanaka (9) in fact, says of this variety that "through cross-pollination or under certain conditions favouring apogamic seed formation, a limited number of seeds are formed".

Oppenheimer (6) submits a considerable body of evidence to favour the view that cross-pollination is responsible for at least a part of the increased seediness found in groves of the Shamouti orange. His figures represent the average number of seeds per fruit, estimated from 25 fruit per tree. Eight selected trees, each growing in the vicinity of another citrus variety, were counted in this way, and compared with similar data from eight controls situated at a distance from other varieties. No statistical treatment of the results is attempted, but the author concludes that they "prove definitely" that Marsh grapefruit, Lisbon lemon, and probably Sweet lime are harmless neighbours for the Shamouti so far as seediness is concerned, whilst the other varieties—Valencia, Baladi (a seeded sport of Shamouti), Duncan, Yusuf Effendi tangerine, and Sour orange*—all cause an appreciable increase in seediness. These results are at least suggestive, but it is worth noting that the *greatest* difference observed in average seed number per fruit between a control and experimental tree is only 3.78, and the mean difference taking into account the whole 16 trees only 0.75. These differences are not such as would be noticed in commercial fruit, nor of course are they comparable with the very large differences at present concerning grapefruit planters in Trinidad.

Oppenheimer also carried out some controlled hand pollinations using pollen of some of the above-named varieties. The results from one such experiment showed that fruit pollinated with Valencia gave 2.1 seeds as against 0 by self-pollination; with Baladi pollen 4.2 against 0.9; with sour orange 5.0 against 0.6; with Sweet lime 0 against 2.3. Four tangerine varieties and the Lu Gim-Gong orange gave in a separate experiment an average of nine seeds per fruit, but no details relating to the number of trees pollinated are recorded. The author also presents figures to show that the flowers of trees giving the larger number of seeds have more viable pollen (as determined by pollen-germination tests), than the flowers of trees yielding sparsely-seeded fruit.

Finally reference may be made to his observation of annual variations in the seed content of a single tree, and his suggestion that weather conditions may be partly responsible, for example by influencing the movements of pollen-carrying bees. This question of climatic effect is an

* No figures are given for Sour orange, but it is mentioned as one of the varieties concerned in the experiment.

important aspect of our problem, but one about which we have no information. Mention might be made here of Coit's (1) finding that in the Washington Navel orange a higher percentage of mature embryo-sacs were found at Riverside, California, than at Whittier where climatic and soil conditions are different. The same author quotes Ikeda (4) as saying that "cross-pollination between seed-bearing and parthenocarpic varieties (of sweet orange) may result in the setting and maturing of fruit containing viable seeds, provided the pollen used is that of a congenial variety". Unfortunately Ikeda's figures are not available to study this contention.

Various observations on the seedlessness of pummelos (shaddocks) may serve to indicate the possible state of affairs in grapefruit, their nearest relative. From Siam, the home of some of the finest seedless pummelos, we have one or two observations on the constancy of the seedless character. Groff (2) mentions that in one of the best districts of Nakon Chaisi the largest crop is picked in November, "though at other seasons the fruits are more seedless". A photograph in the same article of two half-fruits of the Kao Phuang variety, taken from the same tree but at different times of the year, is striking proof of this fact—the one being completely seedless, the other fully-seeded. Groff has also observed trees bearing seedless fruit, except on branches extending towards other varieties of regular seed-producing habits. Torres (10) records the fact that Siamese pummelos, with a reputation for seedlessness, when introduced into the Philippines contain large numbers of seeds in normal-sized fruit, though small or undersized fruit were more or less seedless. The abundant pollen which the flowers from these trees produced was found, on artificial pollination, to be incompatible and no fruit was formed. Cross-fertilization by other citrus varieties in the neighbourhood was therefore strongly suspected as the cause of seediness.

This view meets with the strong support of evidence obtained with pomelos (a different spelling for pummelos or shaddocks, as used here) in Hawaii by Pope (7). Two distinct crops are obtained in Hawaii—a "spring crop" maturing in April, and a "main crop" maturing in autumn. Fruit from the former, set at a time when few other citrus varieties are in flower, is seedless; whilst "main crop" fruit set in the spring when other citrus trees are in bloom, is heavily seeded. In order to substantiate the obvious inference from these facts, Pope carried out an experiment on five grafted Victoria pomelos, three of which were growing in a mixed orchard containing varieties of orange, mandarin, grapefruit, lime and lemon, and two were grown apart, in tubs, 360 feet from the orchard "out of the current of the prevailing trade winds". The latter produced nothing but seedless fruit, even in autumn when the other three in the orchard were heavily seeded. Similarly with the Washington Navel orange, Pope notes a larger proportion of seeded fruit than is usually experienced in California, and attributes it, as well as the seediness of Victoria pomelo, to cross-pollination by the Hawaiian orange, a variety often found in orchards and known to have strong seed-producing habits. In California, the most likely congenial variety is the Valencia, but this is itself sparsely seeded and probably low in fertilizing power. The results of Pope's further work, now in progress, with isolated plantings of Victoria and Siamese pomelos, to prove their self-sterility and study possible congenial varieties, will be anticipated with considerable interest.

(2) Seediness as a Result of Mutation.

There is plenty of evidence in the literature to show that bud-mutation in citrus is a relatively frequent phenomenon. Indeed, so numerous are the variations, involving almost every plant character, which have been recorded as mutations in different varieties—not always with the necessary proof of their mutational origin—that there is a temptation to ascribe every departure from the normal to this cause. Nevertheless, the increasing attention nowadays paid by planters to this aspect of their crop, and their recognition of its dangers by more careful selection of budwood, leads one to suspect that a fairly widespread occurrence of seediness in a "seedless" variety cannot be entirely explained through its agency.

In spite of that it is impossible entirely to disregard the extensive investigations of Shamel, Scott, Pomeroy *et al.* on this subject (8). Marsh grapefruit was among the commercial varieties examined by them, and it is a significant fact that only in this variety was a mutation found affecting the seed content of the fruit. Out of the 500 trees examined by them, 123 or nearly 25 per cent. gave fruits containing 30 to 90 seeds per fruit. They recognised two strains of seedy Marsh which they called "Rough seedy" and "Smooth seedy". Both had a similar characteristic habit of growth which they describe as "drooping", giving to the tree a somewhat dwarfed appearance. In addition, they were usually poor yielders and marked alternate bearers. The leaves are described as "rather sparse, narrow, and very sharply pointed". The following enumeration of the principal characters of the two strains is taken from their descriptions:

"*Rough Seedy Strain*".—Skin coarse, dull yellow, rind c. ½-inch thick; flesh straw-coloured, carpels 12 to 14, rag coarse and unpalatable, vesicles long and large; core usually open, c. 1½ inches diameter; juice abundant, v. acid, poor in flavour; seeds very large—about 50 per fruit.

"*Smooth Seedy Strain*".—Fruit flattened, smooth in texture, rind ivory-white. Very similar in outward appearance to the Marsh strain. Number of seeds usually about 50. Often found on trees with the rough seedy strain. Flesh and juice similar to the latter.

This is the most definite information we have regarding mutations affecting seed content. We may add to that Oppenheimer's (6) opinion that cross-pollination is only one of the factors contributing to seediness in Shamouti. He draws attention to the fact that seeded trees are sometimes found in places isolated from other citrus species, and also discusses the significance of the variety called Baladi which is known to be a seeded sport of Shamouti. Baladi is recognisable on other characters besides seediness, and in some orchards appears fairly frequently, leading to contamination of the crop by inferior fruit. We have here it seems a parallel case to the seedy strains of Marsh. Oppenheimer suggests that the Shamouti may not always mutate to all the characters of typical Baladi, and that seeded Shamouti oranges may be regarded as partial Baladi sports. The proof of this contention lies of course in testing their budded progeny.

D—The Remedy.

From the previous discussion, we have seen that there are at least two sets of circumstances which separately or together may offer a reason for an increase in the seed content of a single "seedless" citrus variety. The remedy will naturally depend upon which of these two factors the results of our practical experiments place the greater importance. At the outset emphasis must be laid on the necessity of ascertaining with certainty that only one variety is concerned, and that no mixture of types, including seeded varieties, has occurred in the course of planting. Varieties of citrus are not always so distinct that they can be exactly distinguished from each other when mixed in the field. In the case of grapefruit, separation is sometimes well-nigh impossible on the basis of botanical criteria, and we are left with the unsatisfactory alternative of judging by such characters as habit, bunching of fruit, colour of flesh or taste, which, relying on personal judgment, is apt to be independable.

Classification and accurate description of horticultural varieties in general can only be made reliable by collecting them into one place for the purpose of keeping comparative records of their habit, growth rate, yield and general behaviour under uniform conditions. Differences between one variety and another may be so small that only by growing them side by side in adjacent plots can they be separated on reasonable grounds. Moreover, descriptions based on such observations must inevitably differ in detail from those of another observer in a separate locality.

It is only begging the question to use the number of seeds as a criterion of variety in this case. By so doing, we ignore the existence of the two factors already spoken about, and this is an untenable view. The fact is not ignored, however, that trees consistently bearing seeded fruit should be regarded with suspicion, and an attempt made to trace the origin of their budwood. At any rate, whether mistakes in budding or distribution can be proved or not, the remedy will be the same as for seedy trees whose origin in mutation has been proved by budding. It should be mentioned here that in re-budding, care should be taken that foreign pollen is excluded from the tree; it would be safer to carry it out in quite a different locality.

The remedy consists in either (*a*) replacing the tree by another, or (*b*) top-working the existing one. Choice of these two alternatives will mainly depend on the age of the tree, the number of trees to be so worked, and the skill of the operator. Where the age of the trees is fairly advanced it will probably be more economical to top-work, only providing that the labourers possess the necessary ability. The method adopted must fully justify its cost, and to those unfamiliar with top-working, a few years lost by raising new plants will be repaid in the better trees they ultimately obtain.

If the seediness of our fruit can be proved not to be transmissible by budwood, we must look to other means of remedying the situation. Concentrating first on the possibility of cross-pollination by congenial varieties near to or within the orchard, these must be sought after by means of observations on the time of their flowering, and the coincidence of this with the period of grapefruit bloom. Their removal can be the only effective safeguard against crossing taking place in future years. Mixed orchards are at all times to be deprecated, and every effort ought to be made to eradicate other varieties where they can be recognised. This should apply even to reputed "seedless" types, since their pollen, though it may be self-sterile, may be fertile with the variety under cultivation.

Attention at this point should be drawn to the possibility of both cross-pollination and mutation operating together. One or perhaps a few trees in the orchard may "throw" a seeded sport bearing pollen which is fertile to the "seedless" variety in question. In this way, a single mutant tree, or even only a limb of the tree, may produce seediness in a number of trees growing near to it. Oppenheimer (6) suggested that this may be the explanation for the reported steady increase in seediness from year to year in a grove of Shamouti oranges in Palestine. An increase in the number of limbs sported to Baladi has here resulted in a greater abundance of fertile pollen being available for seed formation in the adjacent Shamouti flowers.

The only way a grower has of keeping a check on the seediness of his fruit is by counting the number of seeds in a representative sample from each tree. Trees found to bear seedy fruit should be distinctly marked, and their crop marketed separately until an opportunity occurs to remedy the cause. It is suggested that such trees, when

found, should then be examined more closely in order to determine if the seeded fruit are confined only to particular branches. If that is the case, and *if counts in subsequent years confirm the fact*, the grower would be justified in removing the branch on the assumption that it was a mutation. Unless such records are repeated in successive seasons, he has no guarantee that the variation was anything but fortuitous.

E.—Methods of Investigation.

The problems confronting us are purely local in character. From the rapid survey we have made of the results of observers in different foreign countries, we have obtained some insight into the potentialities of citrus fruit in regard to seed formation. These discoveries have to be borne in mind all the time, but they do not answer our local problems. They do, however, suggest two avenues of preliminary approach:

(i) Seed counts of fruit from trees in localities differing with respect to rainfall, soil, aspect, manuring, age, time of flowering and proximity to other citrus species.

(ii) Artificial pollinations to discover which varieties are fertile to Marsh grapefruit, and their effect on seed number.

(i) The principal difficulty in regard to seed counts lies in deciding how many fruits from each tree must be examined to give a valid estimate of the number of seeds per fruit. Shamel, Scott, Pomeroy, *et al.* (8) in their study of bud mutations in Marsh grapefruit separated the fruit into three grades: (*a*) Ivory-white, (*b*) Standard, (*c*) Culls, and from each took three—small, medium and large-sized—fruits. Thus nine fruits per tree were examined yearly for seed number. In this way they obtained a good random sample, but their method, entailing the picking of all fruit from the tree before sampling, is not one which could be practicably applied to commercial estates by the grower himself. He must normally be content to pick his sample direct from the tree, and in so doing attempt to sample all parts of the tree—on all sides, and from the upper as well as the lower branches. Such selection is not strictly at random, but by taking rather more fruits from each tree a fairly reliable estimate should be obtained. Oppenheimer (6), as a result of calculations based on counts from 300 fruits *of a single tree*, concludes that 25 fruits are sufficient to prove real differences between two trees in 95 per cent. of cases. Whilst it would have been more satisfactory to have estimated this minimum number from the records of several trees, it is probable that this figure will be found adequate for practical purposes. Once again, we should stress the need for computing the number from local data, and not placing too great reliance on figures which are the result of totally different environmental circumstances.

(ii) Pollination experiments need not be elaborated here in any detail. The procedure is more or less straightforward, the main difficulties being to obtain pollen from the selected pollen-parent as and when required, and to cover a sufficient number of estates and trees in the brief time a single flowering season will allow. In this connection, intensive work on a few trees will probably yield more valuable results than a number of scattered pollinations embracing a greater number of estates.

The above suggestions will suffice only for a preliminary survey of the situation. Further, more intensive research must await the indications which the data from that survey should provide. In order that the information obtained should be representative of as wide a range of conditions as possible, it will be better at present for the observations to be carried out on different commercial estates throughout the island, rather than to study a small experimental area of clonal trees. The scope of the investigation may have to be narrowed with such a broad field to cover, but the results should be of more immediate value to the grower as a whole.

In conclusion, a plea is forwarded to those concerned in this problem, to free their minds from preconceived ideas on the subject. The solution to the riddle is not likely to be a simple one, a hint as to its complexity will be provided by these notes, so that only carefully recorded and controlled experiments will give any satisfaction when the time comes to apply the remedy.

Acknowledgment.

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THE PRESENT POSITION OF BOTANICAL RESEARCHES ON CACAO.*

By E. E. Cheesman.

Many of you must remember as well as I do an afternoon in April, 1928, when I stood here facing almost the same audience. Your comments were then being invited on a scheme for botanical researches on cocoa, a new born infant to which the chill breath of your disapproval would have been fatal. By your goodwill the child was not only spared but blessed, and in October 1930 was able to walk. It is therefore as much a pleasure as a duty to give you today some account of the toddler's progress during the first five years that I have been privileged to direct it. The review will be as brief as possible, confining itself to the main lines of investigation and omitting many of the more technical aspects, in order that we may have time to discuss the bearing of the results on the present and future of the Trinidad cocoa industry.

As I am to deal strictly with botanical researches, which form only part of the Cacao Research Scheme and a smaller part of all the research that is being done on cocoa production, it may be well to begin by reminding ourselves what they comprise.

I propose to spend most of the time on those researches which concern the genetic constitution, or hereditary make-up of cocoa trees. This is only one factor in commercial cocoa production, and not necessarily even the most important, but it is easily the most important of those which concern the botanist and I hope to show that it is far from negligible to the planter. Meanwhile it is worth mentioning that much of the work of the Cacao Research botanists during the past five years has been directed along other lines. Studies of constitution, the selection of profitable trees, and investigation of propagation methods all imply the assumption that existing cocoa trees have to be replaced by new ones. They are designed to ensure that whenever trees are replaced there shall be better ones to put in their places. There is another set of studies altogether that looks more to the present than the future, and tries to find means of increasing yields on existing trees before they become due for retirement. In this second set of studies the botanist has only a partial responsibility, but still a definite one. Accordingly, we have made among other things a very close study of fruit-setting, to see whether there is anything in fertilization that hinders higher yields. We have studied the relations between change of leaf and the shrivelling of young cherelles, and looked for any simple means there might be of controlling setting so as to avoid the worst effects of unfavourable weather.

I intend to do no more than mention these researches in passing. The results have been published in our Reports, and some of them I hope will in due course find some usefulness. Their interest at the moment, however, is mainly technical. The general conclusion to be drawn from them, as it affects our present discussion, is that there is very little the botanist can do to help with existing trees. Great improvements in the yields of existing cocoa trees are possible, but they lie mainly in the hands of the soil chemist, who can discover suitable manurial treatments, the plant pathologist who can help in controlling pests and diseases, and the planter himself who by proper pruning and other practical operations can both invigorate his trees and reduce pathological losses, always provided that he can find the money.

These considerations bring us back to constitution. If manuring, pruning and more intensive cultivation generally are necessary in any case, as we all believe they are, then it is more than ever necessary to ensure that every picket makes the maximum response to the expenditure upon it, which can only be done by planting the most suitable kind of tree.

Of one other thing we may possibly need to remind ourselves, namely, that our subject for the first part of this talk at least, is research. By that I mean to emphasize that the first duty of research officers is the acquisition of useful information, rather than the collection of specially fine cocoa pods. You will hear a good deal about selection in due course, and I hope you will consider our thirst for knowledge to have been combined with an appropriate appetite for practical applications, but let us not overlook the research aspect, and the real value of knowledge that may be applied by other workers in a rather different way from that in which we happen to have applied it.

With that introduction I must pass to my review, and recount first our attempts to ascertain how yield per acre is built up by botanical factors.

The Analysis of Yield.

There are three components to be reckoned with in estimating productiveness, and each of them proves highly variable :—

Cocoa per acre = Cocoa per pod × Pods per tree × Trees per acre.

With regard to pods per tree, we started with the advantage of information collected since 1910 by your Department of Agriculture, and have nothing to add to previous findings. It would be evident that much of the variation from tree to tree on the average estate springs from causes other than botanical ones, even if you had not listened, a month ago, to a lucid analysis of what

* Being an address delivered to Trinidad Planters at the Imperial College of Tropical Agriculture on 26th March, 1936.

some of the other causes are. There remains a proportion that can only be ascribed to the constitution of the trees, and in that proportion we as botanists are most interested. We do not claim that it outweighs other reasons for low average yields, but we have ample evidence that it is important.

With regard to cocoa per pod, we had a strong hint from Java of what to expect, but no precise information concerning Trinidad trees. Dr. Pound's quantitative survey showed that whilst on the average about 12 pods make a pound of dry cocoa, there are trees from which six or seven are sufficient and others from which more than 20 are required. Therefore of two trees carrying the same number of pods one may be four times as valuable as the other, and even of two trees both above the Trinidad average one may be nearly twice as productive as the other.

There is no doubt that most of this variation is genetic. The amount of cocoa in the pod is influenced like every other part of the tree by soil, weather and agricultural treatment. Some of the effects were measured during the survey, and we know, for example, that from the same tree pods picked at the end of the dry season may contain 30 per cent. less cocoa than pods picked in January. We find also that at one picking there may be almost as much difference between a pod on the trunk and one on a small branch. It is after these variations have been allowed for by taking averages of large samples that the differences between trees still remain. When any visitor to our museum fails to look suitably impressed by the significance of genetic variation in Trinidad cocoa, we show him a specimen exhibiting the thickest and thinnest pod shells found in the survey*. It takes more than environment to produce such a difference, and although the cases are extremes they serve to demonstrate the necessity of weighing the beans before a reliable estimate of yield can be made.

Selection for Yield.

When the quantitative analysis of a representative sample of Trinidad cocoa was complete we were in a position to start selection, but not before. It had become evident that estimating the yields of cocoa trees involved two distinct operations, counting the pods produced and determining the average weight of cocoa per pod. The counting of pods is an expensive operation, because it has to be extended over two or three seasons before the results mean very much. One did not want to keep a lot of trees under observation and then have to discard most of them because their pods were too small. General observation suggested both that small podded trees were unlikely to prove really high yielders, and also that among large podded trees sufficient heavy bearers could be found for our purposes. Influenced further by considerations of quality, which will be discussed later, we decided to confine pod counts to trees which passed a high selection standard for pod size. Here the distribution curves were useful, because we were able from them to fix the standard. About two per cent. of the population or one tree in 50 has pods of which 7½ or less make a pound of dry cocoa, and that was the preliminary standard adopted.

At this point the number of trees per acre began to concern us. We are not interested for the purposes of this discussion in planting distance but in the amount of land an established tree is effectively occupying. No survey was made to determine just how size of tree varies, but a practical correction was applied whenever the yield of a tree was translated into yield per acre. A tree occupying 17 by 17 feet to the detriment of its neighbours planted at 12 by 12 feet has to give twice the yield of an average picket before it is even up to average performance. A tree spreading over 24 by 24 feet has to yield four times the average. This correction removes from the class of true high yielders a great many of the heavy bearers of smallish pods, which make a good show only by smothering their neighbours. Such trees cannot be expected to transmit to their progeny a productiveness that they themselves do not possess.

I have rather emphasised figures in this very bald outline, because they form our only contribution to the study of yield, and must stand as a substitute for any brilliant or revolutionary ideas such as are sometimes supposed to mark real research. The Cacao Research Scheme provided for the first time in Trinidad an officer with time and facilities, unhampered by other duties, to survey these features of the cocoa tree population statistically and to give numerical precision to things that we all knew in a general way before.

The interesting result is that with all three factors taken into account, we can now estimate with reasonable accuracy the rate at which some of the most productive trees in Trinidad produce cocoa. There are a very few actually yielding at present, in various types of soil and without any special treatment, at rates between one ton and 30 cwt. per acre, or 7 to 10 lb. per picket. What we hope will be the useful result is that we have selected 100 of these trees for propagation and further testing by means of their progeny. In every case those that have been selected are surrounded by quite ordinary trees, showing no evidence of being specially favoured by a patch of rich soil or any other local feature. Some of them are quite young and may not have reached their full ability; the older and bigger ones have been appropriately handicapped for size, and show by their survival that they probably have inherent vigour.

* 4.0 and 0.8 cm. respectively.

Ability and Performance.

What trees have done, trees can do, and if the mention of "a ton an acre" is good for a smile anywhere in the Colony at the moment, Dr. Pound and I are quite ready to join in. In proceeding to test the progeny as fast as possible and as thoroughly as possible, we have not yet staked our professional reputations on the result. It is not necessary to assure this audience that we know the gap between *ability* to yield, which is what the botanist tries to select, and actual *performance* as influenced by soil, situation and accidents like falling immortelles.

That same difference between ability and performance, however, has caused so much confusion in the past, in other crops beside cocoa, that I must devote a few words to it. Select a tree that is yielding to the very top of its ability on account of extremely favourable conditions, and its offspring, whether by seedling or by vegetative propagation, are bound to be disappointing. Few if any of them enjoy the advantages that their parent had, and although their average ability is the same their performance drops. In some cases it drops more than in others, because some types suffer more than others from deficiencies in their environment. In extreme cases, one type may go on giving some crop, though a reduced one, where another stops yielding altogether. These facts the selector knows, and he avoids specially favoured trees whenever he can recognize them. Unfortunately he has no method of assessing ability apart from performance, and he is therefore obliged to take the best performers under what appear to him average conditions. Sometimes he makes a mistake and overlooks something in soil, site or treatment that defeats his estimate. These well-known principles of selection are in my opinion sufficient to account for most of the mystery that is supposed to enshroud the transmission of yielding power in cocoa. They account also for the plant breeder's maxim that the only true test of any plant is the behaviour of its progeny. There is no known method of ensuring faultless selection, and that is one reason why there are a hundred trees on our selection list, to allow for disappointments. We make no numerical claim in advance for the progenies of any selections. We do expect a high proportion of them, under fair treatment, to give yields far above the present average, and the reason for our confidence is the care taken in the selection. There for the present I must leave the question of yield and its transmission.

Quality.

Let us now turn to quality, the only factor in selling price that falls within the influence of the botanist. Of uniformity as an important feature in quality I will only remind you in passing, as it is bound up with propagation methods to be discussed later. Intrinsic quality, depending on constitution or breed, provides a more intricate problem than yield, even if it could be taken by itself, which it cannot. It cannot be reduced in a similar way to a statistical basis. There are no precise chemical or physical standards to define it, and the general connection between high quality and high price is too much obscured by market conditions outside our control for either to be a reliable guide to the other.

To add to this initial difficulty, it is clear that neither the highest quality irrespective of yield nor the highest yielding tree irrespective of quality is necessarily or even probably the most profitable to grow. Consequently it is a matter of balance that we have to study, and a balance that will not always be the same even for two adjacent estates, still less for different districts, and less again for the different countries of the British Empire.

So far as Trinidad is concerned, I have previously stated my conviction that some quality premium is essential to the industry. Whether you can increase the premium you already get, or whether the real problem is to maintain it against the tendency to diminution that has been observed, is a question I must leave to business men. Our problem on the research side remains the same, namely to provide something that will give the most profitable balance, under different conditions, not next year but several years ahead. The time factor alone, the obligation laid on the unfortunate botanist to weigh probabilities always ten years or more ahead, is alone enough to justify my description of quality as an intricate question.

The only solution is to provide a range of physiological types, and multiply them all up to a point from which rapid bulking can be carried out when the experimental stage is over. That is the second reason why we have a hundred selections at this stage. They will never be reduced to a single "best" type even for Trinidad, but more probably to the best score or at least dozen.

Criollo Cocoa.

I have now already answered a question put to us from several quarters—"Why bother about any quality except the best?" I will answer it also in other terms, rather more specific. The best quality cocoas in the world are the pure Criollos. Let us glance for a moment at their agricultural history. Grown in Trinidad prior to the disaster of 1727, Criollo has never found favour since, in spite of attempts to re-introduce it. In its own home, Western Venezuela, it has gradually been supplanted by Forastero from the eastern part of the country, till it is said to survive, in anything approaching a pure condition, on only a few estates. Introduced to Ceylon a hundred years ago, to become famous as the "Old Red" cocoa, it has been completely supplanted by a Forastero introduction of about 1880. Established in Java for many years as "Java Criollo", it has given place to hybrids with a Forastero introduction of 1888. Samoa may be added to the list, without even mentioning countries where it has been tried on an experimental scale and got no further.

There is a reason for all this. We hear a lot about the malignant influence of cross-fertilization whenever Criollo and Forastero meet. Cross-fertilization has undoubtedly speeded the disappearance of the white-seeded type. But the real reason is the world-wide preference of planters themselves for the hardier Forastero hybrids wherever they have proved their merits in direct competition with the pure Criollo stocks. Hardiness may mean different things in different cases. In this case it means relative resistance to disease. The Achilles heel, the fatally vulnerable point, of Criollo is its susceptibility to the *Phytophthora* diseases, Black Pod and Canker.

We have heard it said that all this accumulated experience from every cocoa-growing country under the sun goes for nothing, since by the simple expedient of budding Criollo on a Forastero rootstock it becomes as hardy and high yielding as the Forastero itself. I wish that contention could be proved, for our problems would be simplified a great deal. For a rootstock to alter to some extent the susceptibility of the scion to disease is not entirely without parallel, but for rootstocks, and mixed seedling rootstocks of all kinds of constitution at that, to alter susceptibility as radically as it would have to be altered in this case is without any parallel known to me, and certainly without proof in any scientific sense of the term. It is perhaps worth while to point out that the disease concerned in this case is not one primarily attacking the root system or base of the trunk, so that the inherent resistance of the scion itself would have to be affected.

The undisputed possibility of growing Criollo cocoa successfully under certain agricultural conditions, which include factors permitting the use of a very light shade, must not be allowed to confuse the point at issue, which is the susceptibility of Criollo to canker, budded or not. I should be very sorry to be interpreted as ignoring the present very high prices of Criollo cocoa, which obviously allow a margin for yields even below the Forastero average to be profitable, or alternatively allow intensive cultivation and higher costs. I am fairly sure that there are estates in Trinidad as well as Tobago on which Criollo cocoa could be steered safely between the rocks of *Phytophthora* and the whirlpool of thrips. I am no less sure that to many of my listeners a research scheme based on the highest quality alone would be of little interest and less potential profit.

Trinidad Cocoa.

We must, then, study a range of physiological types, including at one end, certainly, the Criollos, but including also at the other end the hardiest types obtainable. Nothing with a quality lower than the present Trinidad average is considered worth a place on the selection list under any circumstances, but even the worst types may have features useful to the plant breeders who sooner or later will follow us, and provision is being made for keeping a few of them under observation, without extensive propagation. The principle of collecting and studying, under different conditions, as complete a range of types as possible, is generally sound for any crop. For a Scheme like ours it is the only one to follow. The one hundred selections from Trinidad cocoa do not, of course, cover the whole range. They are being supplemented, and will continue to be supplemented, by anything of promise that we can get from outside, particularly at the Criollo end of the series. But introducing varieties from outside, with safety, is neither easy, quick nor cheap. It was only common-sense to start our work with the material that lay, so to speak, on our doorstep, and learn something about that before going farther afield. And it is surprising how much of the range can be covered by material obtainable in this Colony.

I want to illustrate that point, because the range of types and conditions in Trinidad forms one of the chief reasons for the Cacao Research Scheme being located here at all. The use of the term "Forastero" to cover Brazilian and West African cocoas on the one hand, and Trinidad, Ceylon, most Venezuelan and a good deal of Ecuador cocoa on the other, sometimes leads to confusion. Confusion of definitions can be the only reason for the suggestion, which has been heard, that all the improvement in quality possible in "Forastero" is scarcely enough to be worth making. In Trinidad, as in other countries where Criollo has ever been extensively grown, even in the past, we have to regard all the existing types as a series of hybrids between Amelonado (or possibly Calabacillo) and Criollo. By generations of cross-breeding the condition is reached which is familiar to all of you and is illustrated by the specimens exhibited.

I can show you something probably very like the original Amelonado parent of Trinidad cocoa. It was collected by Dr. J. G. Myers growing quite wild in the interior of Surinam, under very wet conditions and in dense shade that would be fatal to Criollo. One of the most striking points about it is the *flatness* of its beans. We have no trees in bearing that will represent the probable Criollo parent, so I must show you for comparison some selected Venezuelan beans. Plumpness, even in the Trinidad mixture, serves as some index of quality, because it indicates Criollo genes in the constitution which, whilst conferring size and plumpness on the hybrid confer also other quality factors. It is these Criollo genes, even diluted as they now are, that are responsible for Trinidad cocoa remaining in the "fine" class. I am not overlooking the high standard of preparation that plays its part, but no preparation would make a fine cocoa out of a pure Amelonado. The quality of Trinidad cocoa is an average between extremes, further reduced by the mere fact of mixture. Individuals can be, and are, far above that average, and the important point is that Dr. Pound's selections include many such individuals.

Selection for Quality.

I should explain that at first we were prepared to select for yield and for quality separately, that is to say, to lower our yield standard when we found a specially good bean, or to lower our quality standard when we found an outstandingly heavy bearer. In practice we have in fact done so to some extent. The standards were for our guidance and not for our enslavement. But we found that in general a large pod contains large beans, and consequently the method of selection for yield automatically excludes the poorest qualities of cocoa, the small flat beans. Among those that remain, all above the Trinidad average, some proved to be very much above it on such criteria as we are able to apply in the field.

The occurrence of these relatively high quality types among the highest yielders is most interesting and important. We have seen that so far as the probable parents of Trinidad cocoa are concerned, hardiness and low quality came in together from one side, high quality and susceptibility to disease from the other. It might be expected on general grounds that after several generations of crossing a few individuals in the population would show much of the hardiness of the one parent combined with much of the quality of the other. In that expectation we set out, and I really think it has been justified. When you remember that these 100 trees are the cream of many thousands surveyed, the result is not so surprising as it might at first appear.

I do not wish, however, to exaggerate the quality of the selected trees. Only a certain percentage of them are first class, even according to our standards, and we make no claim that the best of them is a Criollo. With the material available, and in the time that has elapsed, no miracles were to be expected and none has occurred. My object is simply to explain the principles underlying selection, in the hope that you will find them plain and commonsense. I can best summarize the quality question by comparing cocoa selection with the breeding of dairy cattle for the Tropics. You find the pure Friesian or other breeds too susceptible to diseases to be kept economically, and you "grade" with Zebu. You do not call the seven-eighths Friesian a Zebu and then say that the improvement to be effected within the Zebu class is negligible. In cocoa you find the pure Criollo too susceptible to diseases and "grade" with something hardier that is called Forastero. Because the hybrid is also by usage classified as Forastero, it does not mean that the Criollo characters have all disappeared. The only important difference is that in cocoa we have tried to take advantage of Nature's breeding experiments, carried out for 200 years, and consequently we cannot estimate exactly the fraction contributed by each parent. We certainly do not claim as much as seven-eighths Criollo for our hybrids. Later on, it may be necessary to improve on Nature's rather clumsy methods and do some cocoa-breeding ourselves. At the start of a research programme, when time is most precious, is not the time for that.

I want to mention our plans for the immediate future. The field tests of the selections provide for 100 plants of each, vegetatively propagated. The number has been fixed at 100, so that when they come into bearing we can get enough cocoa from each type to prepare adequate commercial samples. Those samples will be the most important test of the principles that have been followed, and the manufacturers' and brokers' reports on them, combined with the yield figures, should show exactly where the balance between yield and quality lies. Until such figures are available you will agree with me that discussions of the exact relations between quality and price must be highly speculative and you will not wish me to indulge in any foolish predictions.

Before leaving the subject of quality, I wish to draw attention to one more aspect of it. I said just now that Criollo genes are responsible for Trinidad cocoa remaining in the "fine" class. I wonder to what extent the worst elements in the mixture are responsible for keeping it near the bottom of that class. There can be little doubt that the beans from the pods requiring about fourteen or more to the pound detract seriously from the quality of the better ones with which they are mixed. Our curve shows that the trees producing them are not a very big percentage of the population. They would be much better out of the fields altogether. The individual planter might gain nothing immediately by removing them, except space in which to put more productive trees, but the general reputation of Trinidad cocoa could hardly fail to benefit, and even if the benefit proved small it would still be in the right direction.

Research in Propagation.

Next I must say a few words about propagation. We have always envisaged vegetative propagation as the only means of producing really uniform cocoa with regard either to yielding power or to quality. There was a method available at the outset in budding, but we have devoted very little research to it, although we have used it extensively in our nursery work. The reasons for that apparent neglect are several, but the chief of them is that we ourselves and our colleagues in other sciences want for experimental use trees that are genetically absolutely uniform, below ground as well as above. So long as seedling stocks were used, there could never be this uniformity and the only way to get it was to root cuttings or layers. Our work on propagation by cuttings might thus be said to be primarily more for ourselves than for you, though the ultimate benefit was intended for the planter. Having got our uniform material we are now in a position to tackle some of the problems of budding, because we have a standard to work to. We can compare

a tree on any stock with the same tree on its own roots, and so assess the value of the stock, which we could not do with any precision before. We hope also to settle once for all whether seedlings as rootstocks have the disadvantages in cocoa that they have in some temperate fruit trees, and I could extend the list of questions that we hope to be in a position to answer by use of these cuttings.

Meanwhile, some of you may be interested in the possibilities of cuttings as commercial planting material in the future. I have had raised a few cuttings, some chupons and some fans, which were rooted by Mr. Pyke rather less than three years ago. Unfortunately I have no note of the exact date, but to the best of my belief they were planted out towards the end of 1933, and are nearer two years old than three. The root systems are in my judgment satisfactory, and in essentials do not differ from those of seedlings raised for comparison. We cannot possibly advocate any extensive use of cuttings before we have had an opportunity to try them ourselves on a field scale, and on various soil types too. At the same time we do not rule out the possibility that in time they may be so used with advantage. I may say that we can now root suitable material almost as easily as we can germinate seeds, and apart from the capital cost of propagators the cost is not high. The care required to establish them in the field, however, is more than that required to establish a seedling, whilst we still have to see what their productiveness will be.

Applications.

That concludes all I have to say strictly by way of review. The bearing of these researches on the present position of Trinidad cocoa calls for a few additional comments. First and foremost there is their relation to the witchbroom scourge. We have heard the opinion expressed that an immune cocoa is the only possible salvation of the Trinidad industry. Without going quite so far, the officers of the Cacao Research Scheme fully appreciate the importance of a resistant variety. In co-operation with the Department of Agriculture steps have been taken to test all our selections and any other promising types that can be found, for immunity. At one time it appeared possible that an immune variety might be discovered somewhere among the extremely mixed population of Trinidad trees. The possibility still remains, but the extensive work of the Department of Agriculture has shown that it is a very slender one. Our main hopes must now be centred on introductions from outside and it does not help anyone to build those hopes too high. Complete immunity has not so far been demonstrated for any type in Trinidad, and degrees of relative resistance are very difficult to estimate, I might say impossible to estimate without extensive and prolonged investigations. The immune type, if it exists at all, may lie concealed almost anywhere between Mexico and Peru, and its discovery may well depend quite as much on luck as on judgment or diligence.

I must not paint too dark a picture. There is a possibility of discovery of a cocoa combining resistance to witchbroom with adequate yield and reasonable quality. One effect of the discovery would be the immediate supersession of all our selections, so far as Trinidad is concerned, and in so happy an event I can assure you that we should not regret their supersession for a moment. But we have to face other possibilities, such as an immune type of such low quality as to be practically useless. We could, and should, start breeding from it and grading up, but there would be several years delay. Add the years necessary to bulk up propagating material, even if the type were available now, and it becomes clear that neither we on the research side nor the planter in rehabilitation of his fields can afford to ignore progress in other directions whilst waiting for the immune type. It still remains true that increased productiveness without immunity would pay for witchbroom control by the established methods over a large part of the Colony.

And so we come to rehabilitation, and the possible contributions of research to that. It may seem inappropriate for a research officer to condone, still more to advocate, methods which clearly fall short of his own ideals. Yet after all even research often has to compromise between the ideal and the practicable, and agriculture always has to do so. We shall save a lot of possible confusion of thought by facing one fact quite frankly. It is ten years too early for the full benefits of our botanical research programme to be available to the public. That truth has never been obscured by us. In 1928 I wrote :—

> "It will be appreciated that some of the most valuable results and especially those on the genetic side cannot be available for some fifteen to twenty years, and the usefulness of the experimental plots should extend over an even longer period."

That cold comfort is only one side of the picture however, and the fact that the time is not ripe for spectacular changes in Trinidad cocoa fields, is no argument against solid if pedestrian advances. With all due allowances made for the witchbroom menace and the economic blizzard, it remains true that the most serious defect in a lot of Trinidad cocoa is the age of the fields. If it is impossible in four or five years to replace the existing trees by a uniform stand of high quality cocoa, vegetatively propagated by the best methods, it remains quite possible to replace those non-productive pickets, to which Prof. Shephard drew attention, with selected seedlings. Granted that these seedlings may not all show the high yields of their parents, with youth on their side they must give more than the non-bearers they replace. Granted that they will not be uniform in quality, a high proportion of them must be above the present Trinidad average, and if a few Calabacillo trees occur among them they can either be budded or re-supplied as the owner prefers. Granted in

short that the process is somewhat rough and ready, if it is the best you can afford it is far better than nothing. It is at the very least cheap and on all grounds likely to show some return; there is no question of heavy expenditure in anticipation of a very dubious result. With even so modest a start rehabilitation will gain momentum until trees of proved performance are really ready for the field. Even they must take their places gradually, and the trees put in now have every prospect of a full economic life before their turn comes for replacement.

To those who prefer budding as a means of replacement, I am quite sure that the Department of Agriculture will afford every assistance in its power, and I can guarantee that we will give the Department in our turn any help that we can, if any is required. I do not wish to occupy more of your time by discussing the *pros* and *cons* of seedling propagation and budding. Quite frankly, at this stage I have a perfectly open mind on the subject myself. The advantages of uniformity disappear unless you are going to replant solid blocks, and when it comes to costs and speed of growth the planter must decide for himself. I would only suggest that before making the decision he should take a look at the seedlings from I.C. selections at River Estate, barely three years old, some of which bore pods this year.

I am truly sorry that cocoa trees will not be hurried in answering the experimenter's questions, and that from a start in 1930 we are able to offer so little precise information in 1936. Dealing with these perennial crops, however, encourages the long view. I have confidence that in due course field trials will reduce the present selections to the best dozen or score and comparisons will finally demonstrate the best propagation methods. Some years later the best Trinidad cocoa fields may really be covered with uniform trees of high quality, bearing with the help of our colleagues of the Chemical Section at a rate—dare I mention it?—of a ton per acre.

In research the last word has never been said, and when that day comes I hope there will be a Professor of Botany in the Imperial College of Tropical Agriculture, to stand at this desk and explain to the planters of Trinidad how, by great improvements on the methods of Cheesman, Pound and their associates he is able to promise (ten years ahead, of course) a super-Criollo, immune from everything.

Acknowledgments.

You have heard during this talk a very frequent use of that convenient and time-saving pronoun, the editorial "we". In conclusion I take the greatest pleasure in acknowledging that most often it stood for one or other of my former assistants, Dr. F. J. Pound and Mr. E. E. Pyke. They, as you know, did most of the work that has been discussed. Together we formed a botanical team, which owes any success it may have achieved to its place in a larger scientific team known as the Imperial College of Tropical Agriculture. Our contacts have been closest with our chemical colleagues, Prof. Hardy and Mr. MacDonald, with Dr. Briton-Jones and with Prof. Shephard, but we have been assisted at one stage or another by almost every member of the staff. In particular, the encouraging interest continuously shown by the captain of the team, Sir Geoffrey Evans, counts for more than I could express in a few words. The Trinidad Department of Agriculture laid a solid foundation of research in Trinidad cocoa on which we tried to build, and Mr. Wortley and his officers have helped us in a hundred ways. Above all I welcome this opportunity of thanking the cocoa planters of Trinidad and Tobago for continued co-operation through a time when you have had much, beside scientific officers, to worry you. I wish specifically to include the cocoa planters of Tobago, with my regrets that distance keeps them from us at this meeting. We have occupied your time, borrowed your labour, tied labels all over your trees and cut your budwood, to mention only a few activities, and anyone who did not know the Colony would be amazed to hear that in all our experience we have never been refused a single facility for which we asked. For that, as well as for your patient hearing this afternoon, I thank you.

PREDICTION OF RUBBER YIELD.

One of the chief problems confronting the rubber research worker is the length of time needed before reliable results as to the yield capacity of the plant can be obtained. The tapping test that is usually employed, conclusive as it is, is only applicable when the latex system is sufficiently developed, that is, a period of seven or more years has to elapse before comparative tests and selection of clones can be carried out. Genetical work is in consequence seriously hampered. A new method, however, has recently been evolved by H. Gunnery (*J. Rubber Res. Inst.*, 6; 1935), by which the yield can be accurately predicted at an early stage in the life-history of the plant. A detailed study of the anatomical structure showed that two distinct types of sieve tubes occur, one of small, the other of large diameter. The latter are invariably associated with latex vessels of wide bore, that is, occur in trees of high-yielding capacity, while the small type of sieve tube is found in low-yielding trees in conjunction with small bore latex vessels. Further, the type of sieve tube is constant in all parts of the plant and at all ages. By means of qualitative analyses of the phloem of young *Hevea* seedlings, therefore, low-yielding individuals may be eliminated at a very early stage, and much valuable time saved in all work of a selective nature.—(*Nature*, Vol. CXXXVI, No. 3446, p. 800, 1935.)

SUGAR-CANE VARIETIES IN ANTIGUA IN RELATION TO (A) INFESTATION, (B) FIELD LOSSES BY THE MOTH BORER (*DIATRAEA SACCHARALIS* FABR.).

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I. Introduction.

In Antigua, the small moth borer is the principal pest of the sugar-cane which is susceptible to attack throughout its entire growing period. Most of the life of the insect is passed within the cane stalk where it is reasonably safe from external adverse conditions. As many as six or more generations of "borer" may develop during the growing period of the cane plant.

Various types of injury may be recognised:

1. *Dead hearts* in shoots of young plant and ratoon cane retarding the general growth of the field.

2. *Bored Canes* due to the tunnelling of the larvae into the stalk. Bored canes may in turn be classified into:

(*a*) "Dead Canes" caused by the production of dead hearts in jointed canes or by canes being broken off at joints weakened as a result of borer attack. Such canes may either be (i) unsaleable, when the canes are killed early, certain weather conditions prevailing, or (ii) saleable, when the canes have been killed only a short time before crop.

(*b*) "Bored Live Canes". These show a reduction in mean joint weight.

(*c*) "Immature Cane" where normal growth has been checked. This is shown by an increase in Brix for bored *vs.* unbored "green" canes.

The following types of injury may be detected at the factory: (i) Direct loss of sugar-bearing tissues actually eaten by the larvae; (ii) Sucrose inverted and spoilt by production of gums and impurities caused by entrance of rot fungi, &c., through broken tunnels (*e.g.*, red rot, *Colletotrichum falcatum*); (iii) Decrease of purity resulting in decrease of available sugar; (iv) Increase in fibre content of cane with resultant decrease in extraction; (v) Presence of decomposition products which increase the viscosity of low grade massecuites and thus slow down the boiling and curing operations.

3. *Damage to planting material* in proportion to the percentage joint infestation. Injured cuttings are especially susceptible to rot, *e.g.*, from "Pineapple Disease" (*Thielaviopsis paradoxa*).

4. *Reduction in the ratooning period* in cases of heavily infested fields.

The following indices are used for expressing the extent of borer attack, (i) Percentage stalk infestation, *i.e.*, the number of bored stalks per hundred stalks; (ii) Percentage joint infestation, *i.e.*, the number of bored joints per hundred joints; and (iii) Intensity Index, *i.e.*, the mean number of bored joints per bored cane.

Joint infestation figures are considered the most reliable, and are generally used when only one index is quoted.

An idea of the infestation occurring in Antigua may be obtained from the following figures quoted by Box (1) in 1932.

Percentage stalks bored (all fields)	73.7
Percentage joints bored (all fields)	16.4
Plant Cane—29 fields, stalk infestation	82.4
Do. do. joint do.	19.5
Ratoon Cane—10 fields, stalk do.	49.5
Do. do. joint do.	7.5

It is generally accepted today that certain varieties of cane are more resistant than others to borer attack. This aspect of the borer problem has been investigated by several workers. Box (2) gives the following figures regarding infestation of different varieties in certain localities in the Argentine.

	Joint Infestation.	*Intensity Index.*
Av. P.O.J. 36	23.4	4.6
Av. P.O.J. 213	36.1	6.0

Corresponding figures from Louisiana are:

Variety.	*% Bored Stalks.*	*Intensity Index.*
P.O.J. 36	37	1.6
P.O.J. 234	59	2.3
P.O.J. 213	89	3.7
Louisiana Purple (Morada)	89	2.0

From an investigation, carried out in British Guiana on ten different cane varieties (as plant canes and ratoons), in which the requirements as regards experimental layout were fulfilled, and the results statistically analysed, Cleare (3) states: "The results obtained show that there is a marked difference to moth borer damage in different varieties of sugar-cane and there are indications that such resistance is capable of transmission". Wolcott (4) as quoted by Cleare (3) states, "Whatever may be the cause of the difference in infestation of the varieties, its practical importance to the cane grower is that when it is practicable to grow Yellow Caledonia and Cavengirie and possibly B. 3142 borer infestation is automatically reduced."

Tucker (5) working in Barbados offers an explanation for the differences exhibited in different varieties to moth borer. He suggests that the following three factors in cane varieties are likely to affect the extent of egg deposition by *Diatraea* and the rate of larval survival, and therefore of borer attack.

1. *Chemotropism to the cane plant.*

There is probably a definite chemotropism due to the odour of plants which attracts borer moths. If this attraction is stronger on the part of any one variety of cane more moths will fly to fields of this variety.

2. *Oviposition stimulus.*

It is possible that the smoothness or roughness of the cane blade may influence the number of

egg masses deposited and number of eggs per mass. These two factors however are difficult of measurement and therefore no evidence is available.

3. *Ease of larval feeding and penetration and therefore of survival.*

Evidence has been obtained to show that extent of borer infestation is correlated with percentage dry matter in the central spike. The lower the percentage dry matter, the greater are the chances of survival of the newly hatched larvae, hence the greater the infestation.

Recently, T. E. Holloway (8) suggested the possibility of minimising losses from borers by the employment of resistant varieties. From an examination of a number of cane varieties with reference to the proportion of stalks and of joints bored and to the number of egg clusters occurring, it was deduced that certain varieties were more resistant than others. The most resistant cane of all, P.O.J. 36 M., was derived from a cross between Chunnee and a resistant variety (Louisiana Striped), while the others were all derived from a cross between Chunnee and a susceptible variety (Louisiana Purple). This suggests that the factors responsible for resistance are hereditable.

While assessment of the joint infestation in different cane varieties affords a means of roughly comparing the intensity of injury, it does not necessarily follow that the measurable field loss is directly proportional to the joint infestation. An opportunity arose whereby the writer was able to examine this point under controlled conditions.

The investigation involved a comparison of carefully determined borer infestation with the measurable field loss, of the varieties grown in the course of three* varietal experiments. This experimental work was conducted by the Department of Agriculture under the guidance of Dr. McIntosh of the British West Indies Central Cane Breeding Station.

Some very suggestive data have been obtained, sufficiently definite to warrant publication, though indicating the need for further work on similar lines.

The experimental layout of the fields examined is shown in Figs. 1 and 2.

* Owing to the prevalence of root disease the results of one experiment were excluded.

Fig. 1.—Plan of Paynter's Experiment.

Soil type : Non-Calc. Clay-Tuff.
Layout : 4 Randomised Blocks.
Varieties : Ba. 11569, B.H. 10/12, B. 4507, B. 2935, B. 726, S.C. 12/4, P.O.J. 2878
Rainfall : 50 inches.
Planted : 9/1/34. *Reaped* : 21/3/35.

A1 Extra	A2	C1	C2 Extra
B. 2935	B.H. 10/12	Ba. 11569	B. 726
A3	A4	C3	C4
B. 2935	B. 4507	B.H. 10/12	P.O.J. 2878
A5	A6	C5	C6
B. 726	S.C. 12/4	B. 2935	B. 4507
A7	A8	C7	C8
Ba. 11569	P.O.J. 2878	S.C. 12/4	B. 726
B1	B2	D1	D2
B.H. 10/12	B. 726	B.H. 10/12	B. 2935
B3	B4	D3	D4
P.O.J. 2878	Ba. 11569	B. 4507	P.O.J. 2878
B5	B6	D5	D6
B. 2935	B. 4507	S.C. 12/4	B. 726
B7 Extra	B8	D7	D8 Extra
B. 2935	S.C. 12/4	Ba. 11569	B. 726

Fig 2.—Plan of Collins' Experiment.

Soil type : Calc. Marl.
Layout : 4 Randomised Blocks.
Varieties : Ba. 11569, B.H. 10/12, B. 4507, B. 2935, B. 726, S.C. 12/4, P.O.J. 2878
Rainfall : 42 inches.
Planted : 28/12/33. *Reaped* : 12/3/35.

Extra	A1	B1	Extra
B. 726	B. 726	B.H. 10/12	B. 726
A2	A3	B3	B2
B.H. 10/12	P.O.J. 2878	B. 4507	S.C. 12/4
A4	A5	B5	B4
Ba. 11569	B. 2935	B. 726	P.O.J. 2878
A6	A7	B7	B6
B. 4507	S.C. 12/4	Ba. 11569	B. 2935
C1	C2	D1	D2
S.C. 12/4	B. 2935	B. 726	P.O.J. 2878
C3	C4	D3	D4
B. 4507	B. 726	B. 4507	Ba. 11569
C5	C6	D5	D6
P.O.J. 2878	B.H. 10/12	S.C. 12/4	B.H. 10/12
Extra	C7	D7	Extra
B. 2935	Ba. 11569	B. 2935	B. 2935

N.B.—Plots marked "Extra" not in experiment.

II. Experimental Procedure.

(*a*) *Field Loss.*—To arrive at the percentage losses in weight sustained by the different varieties, ten stools of each were examined in each plot giving a total of forty stools of each variety. This number was considered sufficient to give a fair average, and to allow statistical analysis of the results.

All the canes on each stool were cut and sorted into four classes :

(1) Canes unattacked by borer or " Borer Free " canes.
(2) Canes attacked by borer but still alive.
(3) Canes killed as a result of borer attack but still in a saleable condition.
(4) Canes killed as a result of borer attack and non-saleable.

In addition to these four classes there was a certain number of canes rendered unsaleable by causes other than borer. These were discarded and no account taken of them. The total number of canes considered was therefore the total number which should have developed had no borer been present.

The total number of canes in each class was ascertained and weighed except class 4, because this in reality represented a 100 per cent. loss to the cane grower. The average weight per cane of each class was then calculated. It was originally intended to calculate the losses on the average weight of " Borer Free " cane. After reviewing the results obtained, however, it was decided to represent the potential average weight per cane by the average weight of " Borer Free " plus " Bored Alive " canes, *i.e.*, of classes 1 and 2. This method was used because under the conditions of low percentage joint infestation which obtained at the Collins experiment, the differences in weight between classes 1 and 2 were too small to be easily measured. In the case of the Paynters experiment, however, the percentage joint infestation figures were of a much higher order, and in this case, there being so few " Borer Free " canes, a fair average weight could not be obtained. The following illustrates the manner in which the losses were arrived at.

Let X = total number of canes collected from 40 stools (all classes).
Let Y = total weight of canes collected from 40 stools.
Then $\frac{Y}{X}$ = actual average weight per cane $= a$.
Let x = total number of canes comprising classes 1 and 2.
Let y = total weight of above.
Then $\frac{y}{x}$ = potential average weight per cane $= b$

$$\% \text{ Loss} = \frac{(b-a) \times 100}{b}$$

(*b*) *Infestation.*—The three values commonly used in estimating borer attack were calculated as previously shown. Counts were made on 5 of the 10 stools per plot used in estimating percentage loss in weight, giving a total of 20 stools for each variety.

ANALYSIS OF RESULTS.

Table I.
Classification of Canes.

Varieties at (i) Paynters Experiment.	Unbored.	Bored. Alive.	Bored. Dead. Saleable.	Bored. Dead. Unsaleable.
	I	II	III	IV
B.H. 10/12	0.8	80.3	17.4	1.5
Ba. 11569 ..	0.8	84.7	10.8	3.7
S.C. 12/4 ..	0.6	87.3	6.6	5.5
B. 4507 ..	0.8	82.6	9.3	7.3
B. 2935 ..	Nil	80.9	15.5	3.6
P.O.J. 2878	Nil	71.0	16.2	12.8
B. 726 ..	Nil	81.3	15.4	3.3
(ii) Collins Exp.				
B.H. 10/12	41.1	55.4	2.3	1.2
Ba. 11569 ..	40.8	56.2	2.0	1.0
S.C. 12/4 ..	58.0	40.5	Nil	1.5
B. 4507 ..	35.4	60.0	2.3	2.3
B. 2935 ..	45.0	52.2	2.8	Nil
P.O.J. 2878	27.8	65.4	4.9	1.9
B. 726 ..	37.7	60.2	2.1	Nil

Table II.
Comparison of Loss in Weight with Indices of Damage.

Varieties at (i) Paynters Experiment.	Per cent. Loss in Weight.	Per cent. Stalk Infestation.	Per cent. Joint Infestation.	Intensity Index.
Ba. 11569 ..	9.00	100	27.3	5.9
B. 726 ..	9.52	98.5	24.2	5.8
S.C. 12/4 ..	9.61	98.6	20.6	5.2
B.H. 10/12	10.46	98.2	22.9	5.2
B. 2935 ..	11.34	100	21.4	5.5
B. 4507 ..	11.56	97.1	24.0	4.4
P.O.J. 2878	19.26	100	32.0	5.7
(ii) Collins Exp.				
Ba. 11569 ..	2.32	54.3	7.0	2.6
B. 726 ..	1.92	58.0	5.8	2.2
S.C. 12/4 ..	1.65	42.5	4.3	2.3
B.H. 10/12	2.82	62.5	7.3	2.5
B. 2935 ..	2.16	56.0	5.9	2.2
B. 4507 ..	3.68	62.0	7.4	2.1
P.O.J. 2878	4.56	65.0	10.7	2.8

III. Analysis of Results.

Table I (Paynters Experiment) shows that the percentage of canes killed by borer, classes 3 and 4, varies from 12.1 (S.C. 12/4) to 29.0 (P.O.J. 2878). Of the unsaleable canes the lowest figure is 1.5 (B.H. 10/12) whilst the nighest is 12.8 (P.O.J. 2878). As regards the live canes, classes 1 and 2, practically 100 per cent. are bored in each case.

(Collins Experiment). The percentage of canes killed by borer, classes 3 and 4, varies from 1.5 (S.C. 12/4) to 6.8 (P.O.J. 2878), whilst the unsaleable canes, class 4, varies from 1.0 (Ba. 11569) to 2.3 (B. 4507). The percentage of canes actually attacked by borer shows a variation from 42.0 (S.C. 12/4) to 72.2 (P.O.J. 2878).

Table II presents the percentage losses in weight for the different varieties, as well as the indices usually employed to indicate the intensity of attack by borer, *viz.*: percentage joint infestation, percentage stalk infestation and intensity index. The results obtained in the case of percentage losses and those of percentage joint infestation were statistically analysed by Fisner's analysis of variance method in order to test whether the differences obtained were due to borer or merely differences due to chance. Results were obtained as follows :

(*a*) Paynters Experiment.

(i) Percentage Losses.

Calculated value of Z = .6265.

Observed value of Z from Fisher's Tables for prob. .05 = .4894

∴ the experiment shows a general significance.

Standard Error of Differences between means = 2.659

From Fisher's Table of t.

t for prob. .05 and random variance 18 = 2.101.

Differences must exceed 2.659 × 2.101 = 5.5 per cent. (approx.).

P.O.J. 2878	19.26
B. 4507	11.56
B. 2935	11.34
B.H. 10/12	10.46
S.C. 12/4	9.61
B. 726	9.52
Ba. 11569	9.00

It can be stated therefore that the variety P.O.J. 2878 shows a significantly greater percentage loss as a result of borer attack than do the other varieties. The other varieties show no differences among themselves.

(ii) Percentage Joint Infestation.

Calculated value of Z = .6982.

Observed value of Z from Fisher's Tables for prob. .05 = .4894

∴ the experiment shows a general significance.

From Fisher's Tables of t.

t for prob. .05 and random variance 18 = 2.101

Standard Error of Differences between means = 2.405.

Differences must exceed 2.101 × 2.405 = 5.05 (approx.).

P.O.J. 2878	32.0
Ba. 11569	27.3
B.H. 10/12	22.9
S.C. 12/4	20.6
B. 726	24.2
B. 2935	21.4
B. 4507	24.0

It can be stated as a result of this experiment that : Firstly, P.O.J. 2878 shows a significantly greater effect of borer attack than all the other varieties except Ba. 11569 ; secondly, Ba. 11569 shows a significantly greater effect of borer attack than B. 2935 and S.C. 12/4 ; and, thirdly, the remaining varieties exhibit no significant differences among themselves.

(*b*) Collins Experiment.

The varieties showed no significant differences from the effects of borer attack as measured by percentage loss in weight or percentage joint infestation.

Table III shows the actual and potential yields of the different varieties.

Table III.

Assessment of Losses in Tons per Acre.

Variety.	Paynters. Yield.			Collins. Yield.		
	Actual.	Potential	Loss	Actual.	Potential	Loss
B. 2935 ..	33.0	36.7	3.7	28.8	29.4	0.6
Ba. 11569 ..	30.5	33.2	2.7	28.1	28.7	0.6
P.O.J. 2878	29.7	35.4	5.7	25.2	26.3	1.1
S.C. 12/4 ..	29.4	32.2	2.8	22.5	22.9	0.4
B.H. 10/12	26.9	29.7	2.8	26.3	27.0	0.7
B. 726 ..	26.4	28.9	2.5	22.2	22.6	0.4
B. 4507 ..	25.3	28.2	2.9	22.3	23.1	0.8

The results of the experiment on actual yield figures were as follows :

Paynters.—For prob. 0.05 differences must exceed 3.66 tons.

Collins.—For prob. 0.05 differences must exceed 7.49 tons.

It is interesting to note that the differences in yield exhibited by the varieties, as shown by the actual yield figures, with the exception of P.O.J. 2878, are practically the same as the differences between varieties as shown by the potential yield figures. (*See* Fig. 3.)

The losses per acre vary from 5.7 tons (P.O.J. 2878) to 2.5 tons (B. 726) in the Paynters experiment, and from 1.1 tons (P.O.J. 2878) to 0.4 tons (B. 726 and S.C. 12/4) in the Collins experiment. Thus, as a result of borer attack, P.O.J. 2878 was reduced from a potential yield of 35.4 tons to an actual yield of 29.7 tons, causing this variety to be displaced by Ba. 11569. In the Collins experiment the order of merit was unchanged.

IV. Discussion of Results.

These experiments indicate that at relatively low infestations such as were obtained in the Collins experiment, the losses sustained are relatively not of a serious order, and varietal differences are not easy to discern. With increases of borer infestation, however, as at Paynters, the losses sustained become more evident while varietal differences are accentuated and are more readily measured and statistically analysed.

In most other investigations carried out on this subject, varieties have been compared, using percentage joint infestation as the criterion of borer attack. According to the results obtained in this investigation, it would appear that a high percentage joint infestation is not necessarily correlated with high material damage. Comparing the varieties on percentage joint infestation figures alone (*e.g.*, at Paynters) there is nothing to choose between P.O.J. 2878 and Ba. 11569, and the latter shows a significantly greater percentage joint infestation than B. 2935 and S.C. 12/4. Regarding the losses sustained as a result of borer damage on the other hand, P.O.J. 2878 shows a significantly greater loss than any other variety, and the difference between the others is shown to be non-significant.

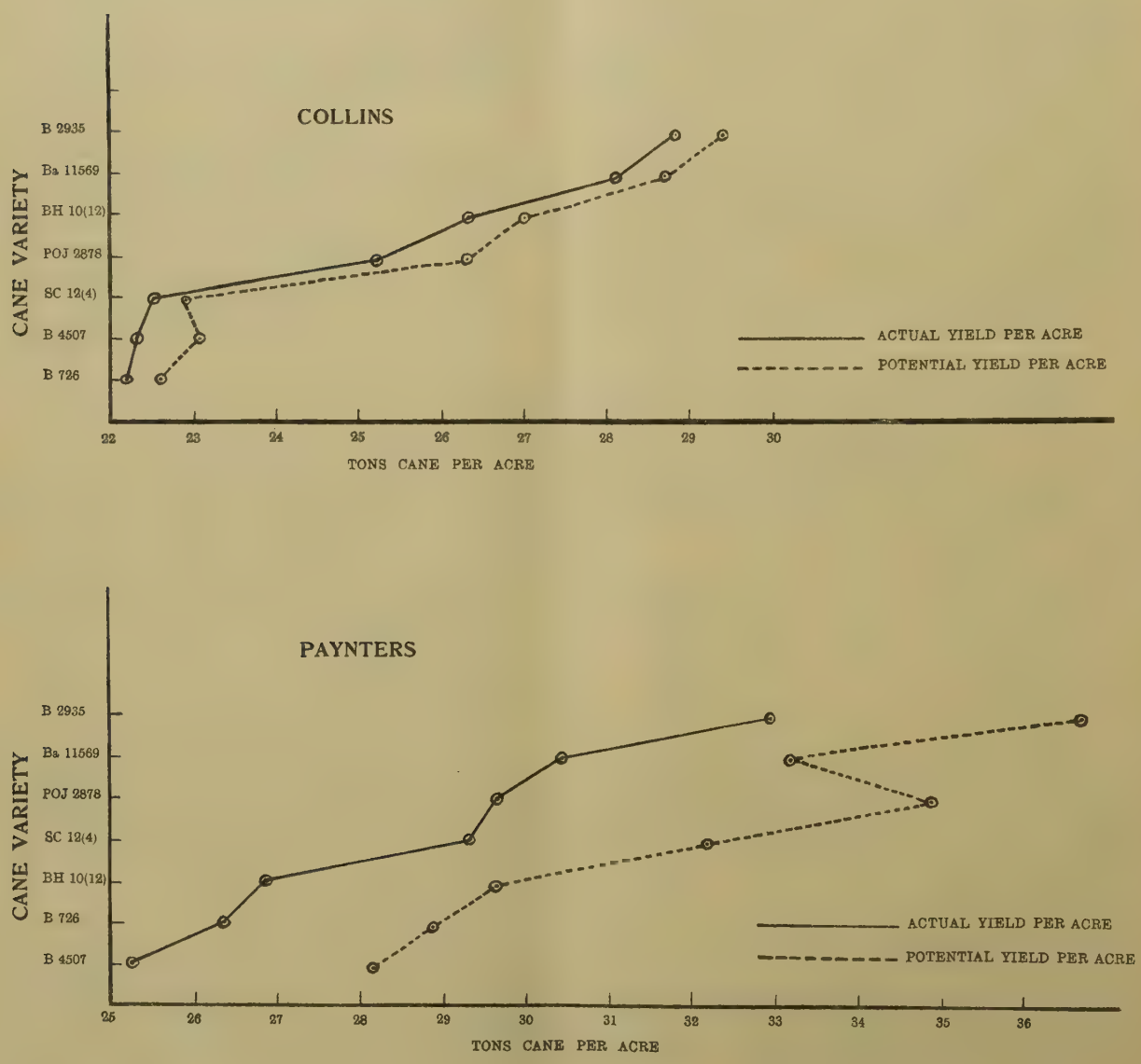

FIG. 3.

V. Summary.

1. Various types of injury to sugar-cane by the small moth borer are described.

2. Previous investigational work in connection with differences in varietal susceptibility to borer is presented.

3. Two variety trials laid out according to modern experimental methods were examined with reference to (*a*) infestation, (*b*) percentage loss in weight by the moth borer. The data obtained are given and statistically examined.

4. Results obtained show that (*a*) percentage loss in weight is not necessarily proportionate to percentage joint infestation, (*b*) there is a significant difference between varieties when compared on measurable field losses (percentage loss in weight).

Acknowledgments.

The writer wishes to express his thanks and appreciation to Mr. H. E. Box, Entomologist attached to the Advisory Department of the Imperial College of Tropical Agriculture, for the keen interest he has shown in the work as well as for his valuable aid in the interpretation of the results obtained. He also wishes to thank the Editor of the College Journal and Mr. A. Pickles, Entomologist of the Department of Agriculture, Trinidad, for valuable criticism in connection with the presentation of the paper for publication.

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THE 1935 DATE HARVEST.

Prices.

THE opening prices of the season for Basrah's three main commercial varieties of dates were fixed as follows :—

	£	s.	d.	
Hallawi	10	18	2	a ton
Khadrawi	6	0	0	do.
Sayir (*i.e.*, Usta 'Imran)	5	0	11	do.

In 1934, the corresponding prices were £8 3*s.* 8*d.*, £6 0*s.* 0*d.* and £4 18*s.* 2*d.*

In the United States, which is the chief market for Hallawi, prices have dropped, but, despite this, the serious shortage of this variety due to the attack of the date bug in May and June has forced up the Basrah prices. The price for Sayir is also higher, as this can, to some extent, replace Hallawi on the United States market; that for Khadrawi, which is chiefly exported to Australia, remains unchanged.

Export.

The 1934 export crop*, at the time the price was fixed, was as follows :—

	Tons.	*Tons.*
Hallawi	33,000	(33,000)
Khadrawi	6,000	(7,000)
Sayir	50,000	(52,000)
Other Varieties	41,000	(63,000)
Total	130,000	(155,000)

Actual exports are shown in brackets. The 63,000 tons shown as "Other varieties" is actually the weight of Zahdi only. Figures for the remaining exports are, however, unlikely to reach 1,000 tons.

The 1935 season's exports are estimated as follows :—

Hallawi	26,000	tons.
Khadrawi	6,000	,,
Sayir	52,000	,,
Other Varieties	56,000	,,
Total	140,000	,,

As already noted, the Hallawi crop is short owing to the attack of the date bug: good quality Khadrawi is a little less than last year: Sayir seems about the same. Most of the Zahdi exported from Basrah comes from the Euphrates, so that reductions may be expected in the large 1934 deliveries owing to the prolonged anti-conscription disturbances there.

Quality of Crop.

The hot damp weather during most of the 1935 summer and the absence of the usual dry N.W. winds have resulted in a better quality Hallawi crop than has been seen in Basrah for many years. Thus, whereas in 1934 a third of the Hallawi crop was exported in baskets, the proportion will be much less for the 1935 crop. Khadrawi is, perhaps, a little below 1934 quality; Sayir is of average quality.

V. H. W. D.

* *Tropical Agriculture*, Vol. XIII, No. 1, p. 19.

REVIEWS.

SOILS—THEIR ORIGIN, CONSTITUTION AND CLASSIFICATION.

By G. W. Robinson. *T. Murby & Co.*, London, 1936, Second Edition, 20*s.*, pp. 442.

The fact that a new edition of Professor G. W. Robinson's book is already demanded (the first was published in 1932), indicates the need for a book of the scope of this one, and the great success of its author's efforts to meet that need. The first edition was reviewed in *Tropical Agriculture*", at p. 381, Vol. IX, No. 12, December 1932, where a list of contents of the book was given. The new edition differs from the first in that the subject matter has been extended by some 60 pages, and the list of references by 150 additional entries. Certain statements and explanations have been clarified, and parts of the text have been amended in view of recent advances in the science of the soil, notably the discussions of pedogenic processes, the clay complex, base exchange, soil moisture and soil classification. Professor Robinson's book records his own view of Pedology, and is "not intended to be an impersonal and impartial account"; it is a "picture rather than a photograph", and the facts have been arranged so as to present the author's particular perspective. Since Professor Robinson's long experience and philosophic interests cover a very wide field, embracing both geological, geographical and agricultural aspects of the soil, and since his reputation is international, students would be well advised to trust to his guidance. The reviewer uses this book in his own classes, and strongly recommends it to all who need a broad treatment of the subject of soils presented in a readable and interesting manner.

F. H.

* * *

ELEMENTARY MICROTECHNIQUE.

By H. Alan Peacock, M.Sc. *Edward Arnold & Co.*, London, 1935, pp. 200. 5*s.* 6*d.*

Without a practical acquaintance with this work, it is safe to say that the author has succeeded in his object of producing an inexpensive, concise reference book giving in handy form all the most useful information contained in the larger, less-easily available treatises on cytological and histological technique. It is a practical handbook of wide usefulness, which will be appreciated not only by students, for whom it is primarily intended, but also by those in charge of general botanical and zoological laboratories to whom the larger works are an unnecessary expense.

The earlier chapters are concerned with an outline of the technique involved in the standard methods of preparing animal and plant tissues for microscopical examination. The descriptions are straightforward and clearly written in a logical sequence, special stress being laid on the *reasons* for the different steps, and the *causes* of the reactions. The remaining three sections, occupying the greater part of the book and arranged alphabetically as an index with cross-references, deal with methods for specific purposes, the uses of stains, and sundry formulae and hints on practical procedure. Additional information is included in three appendices concerning culture media and methods of culturing, preservation of material for museum purposes, and a short bibliography of textbooks on the subject. The author makes no claim to originality in the methods and formulae he describes, though these are well up-to-date; but his choice of the most serviceable data, and the compactness of its compilation, assure for his book a constant use by a wide circle of biologists.

N.W.

* * *

EARTHQUAKES AND MOUNTAINS.

By H. Jeffreys. *Methuen & Co. Ltd.*, London, 1935, pp. 183, + 6 plates and 9 maps and diagrams, 7*s.* 6*d.*

This book describes in simple language the physics of the earth, and is a summary of the author's larger work "The Earth", published in 1929. It starts with an account of the mechanics of solids and fluids, which leads to a discussion of the strength of rocks and the conditions under which rock strata may be bent, folded, fractured, or even caused to flow like a viscous fluid. Earthquakes are due to rock fracture which generates waves that travel through the earth. The earth is solid to a depth of about half its radius, and liquid at the core. The wave motion occurring in the solid part may be very complicated; its main features and measurement are described in Chapter II. The shape of the earth and the meaning of gravity are discussed in Chapter III. The distribution of high land and of gravity necessitates that the strengths of the strongest known surface rocks extend down to depths of over 30 miles, and in regions subject to deep-seated earthquakes, reduction in rock strength apparently does not begin until depths over six times this magnitude are reached (Chapter IV). The changes that the chemical compounds comprising the material of the earth undergo during natural processes of denudation, erosion, weathering and deposition are described in Chapter V. Studies of radioactivity of minerals indicate that the age of the earth lies between 1,500 and 3,000 million years. The question of the earth's origin is fully considered in the light of geophysical evidence. In Chapter VI, tides and the effects of tidal friction are discussed, and in the last chapter, the mechanics of geology is explained with reference to mountain building and tectonic structures developed in rock strata by crustal contraction.

It is impossible in a short review to summarise adequately the main facts and theories that have been elucidated during recent years, and which

form the main thesis of this most interesting book. To those observers who are fascinated and awed by the manifestations of the forces of nature expressed in the magnificence of mountains and the threat of earthquakes, Dr. Jeffreys' book will have a great appeal, and will be found well worth the effort of a careful study of its contents.

F. H.

* * *

HISTORICAL GEOLOGY OF ANTILLEAN-CARIBBEAN REGION.

By Ch. Schuchert. *John Wiley & Sons*, New York, 1935, pp. 811, 117 figures, 50s.

This monumental work is the outcome of Professor Schuchert's stratigraphical teaching at Yale University. It is divided into four unequal sections. The first (57 pages) describes in summary form the chief geological features, earth movements and fossil relationships of the strata occurring within the region. The second (20 pages) discusses the three great ocean basins of Central America, namely the Caribbean Mediterranean Sea, the Antillean Sea and the Gulf of Mexico. The third (33 pages) deals with the biological evidence having bearing on the relationships of the land masses evolved during the geological periods. The last section (656 pages) describes the detailed geology of the different areas within the Antillean-Caribbean Region, namely, Mexico the Gulf Coastal Plain, Central American countries, the Greater Antilles (including the Bahamas), the Isthmus, Northern South America (Colombia, Venezuela, Trinidad, Tobago and Barbados), and the Oceanic Islands or Lesser Antilles (including Bermuda). A copious bibliography is appended to each section, and numerous maps, diagrams and tables illustrate the subject matter throughout. 16 palaeographic maps at the end of the book depict the distribution of land and sea during different geological periods since late Paleozoic times, thus epitomising in simple manner the geological history of the region.

The book is not easy reading, but it is a mine of information, and is indispensable to anyone interested in the geological development, stratigraphical relationships and petrology of the region with which it deals. The text is beautifully printed, and the subject matter is well arranged. A full index and the numerous bibliographies add greatly to the book's usefulness. Unfortunately, some of the maps are not very clear, being overcrowded with detail. Several reproductions of photographs of eminent geologists who have worked in the region add to the interest of the work.

F. H.

MINERAL NUTRITION OF PLANTS.

ZINC sulphate has been used successfully to "cure" a number of different kinds of plants affected with certain so-called diseases. Such results were obtained by Mowry and Camp with "bronzing" of tung-oil trees, Barnette and Warner with chlorosis or "white-bud" of corn; Chandler, Hoagland and Hibbard with "little-leaf" of peach, plum, apricot, apple, walnut, grape, fig and other plants; and by Dufrénoy with *court-noué* of grapes. The zinc in the various experiments was incorporated into the plant in various ways, such as by applying the salt to the soil, bark, or leaves, in a hole in the stem, or in some cases by driving pieces of the metal itself into the tree trunk.

An insufficient supply of boron was found to be the cause of "corky-pit" of the fruit of the apple, the fruit from such trees having, according to Askew, about one-third as much boron as that from healthy trees; Atkinson cured this condition by putting boric acid into a hole bored in the stem of the tree. Hughes and Murphy confirmed Brandenburg's previous report that crown rot of sugar beet is due to boron deficiency.

Copper sulphate, added at the rate of 50 lb. of copper sulphate per ton of the usual forms of fertilizers, increased by about 10 per cent. the yield of tobacco, cotton and field corn, and possibly of sweet potatoes and squash, according to extensive tests on soils low in copper in Virginia, the Carolinas, and Georgia by Russell and Manns. But Caldwell showed how, in some cases, a small amount of copper may become injurious; he found that with greenhouse-grown potted cucumber plants, what appeared to be a mosaic disease was caused by copper poisoning due to washing the pots in a copper boiler.

Young found that increases in the growth of timothy were obtained by adding solutions containing small amounts of Mo, Sb, Bi, Ce, Sr, W, U, Yt, Cd, La, Be, Li, Th, V, Zr, or other elements, to a fertilizer mixture applied to Merrimac coarse sandy loam. The growth of algae on the surface of the soil or in flask cultures was found to be a good indicator of the nutrient effect on higher plants of added chemicals. A quantitative measure of algal growth was obtained by colorimetric estimation of the extracted chlorophyll.

Rapid methods of determining the usual fertilizer needs, especially of phosphorus, potassium and nitrogen have been developed by Thornton, Connor, Fraser, Gardner, Robertson, and Emmert. The composition of extracts of the petioles, midribs of leaves, and other conducting tissues of the plant was found to be of value in indicating soil nutrients which should be added, availability of ions from different fertilizer sources, whether a soil was supplying too much of a given nutrient in relation to other nutrients, and what adjustment of fertilizer applications should be made from time to time.—(*Ind. & Eng. Chem., News Ed.*, Vol. XIII, No. 24, 1935, p. 474.)

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Storage and Handling of Surplus Bagasse. *W. J. Harper.*

As all available space in the bagasse loft (at Mossman Central, Queensland) had been filled, means for the transfer of this surplus outside the mill and to store it in the yard had to be devised. This was satisfactorily accomplished by a steam blower, placed under a regulating slide in the bagasse conveyor, and operated by the loft man. After several months it was necessary to transfer some of the bagasse back to the loft, but the blower proved impossible for this purpose, due to the bagasse having become compacted in storage.

Since it was impracticable to break up the lumps before feeding to the blower, other methods of disposal had to be sought. An elevator, of the endless chain and drag type was used. This was so designed that the foot of the elevator could be moved about to facilitate the feeding of the bagasse which was then raised and delivered into the bagasse carrier. In this way the removal and return of surplus bagasse from and to the bagasse carrier, were successfully accomplished.

During the period of storage there was no rain, and a temporary roof consisting of sheets of iron nailed to battens was laid over the top. Subsequent rains ran from this roof down the sides of the pile. After 12 months the condition of the bagasse was good, but it was noticed that portions in which molasses had been incorporated had deteriorated to a much greater extent than those not so treated; the former appeared dark brown in colour and was somewhat powdery. Consequently it would appear that molasses and bagasse should be stored separately.

Samples of bagasse were drawn from various portions of the heap and sent to the Bureau of Sugar Experiment Stations for analyses. The following results, in B.T. Units per lb., were obtained, as set out in the following table:—

	Well Preserved Sample.	*Deteriorated Sample.*
Calorific value, dry basis	8292	8031
Calorific value, dry ash-free basis	8384	8302
Ash, per cent.	1.10	3.26

Since molasses was incorporated within the bulk from which the deteriorated sample was drawn, this doubtless contributed in some measure, at least, to the decrease in calorific value and increase in ash content.

Whilst lying in a compact heap, the bagasse was tested to see whether there was any appreciable temperature rise due to decomposition. The maximum temperature recorded was 180°F., and as the charring point of bagasse is over 300°F., there appears to be little danger of spontaneous combustion taking place.—(*Inter. Sugar Journal*, Vol. XXXVIII, No. 447, p. 113, 1936.)

Morgan Cane Mill Disintegrator at Central Aguirre (Puerto Rico). *Norman Kay.*

"We have now finished our second crop at Central Aguirre with this machine, located in front of a 12-roll, 34 in. × 78 in. mill. In spite of the fact that this mill is too compact for the most efficient operation, the results have been highly satisfactory. Figures are as follows:—

Cane ground	231,369 tons
Cane per hour	90.6 do.
Sucrose in bagasse	2.66 per cent.
Moisture in bagasse	47.72 do.
Dilution of mixed juice	17.30 do.
Sucrose extraction	95.63 do.
Tons cane per ton 96° sugar	7.53 do.

"This result was accomplished without a single stoppage or mishap to the machine. With a greater amount of maceration, much better work would have resulted. With the limited amount of water that our present equipment can evaporate, a good percentage of dry fibre passes through the mills. In the face of that, however, we have increased our tonnage and sucrose extraction over previous years.

"The bagasse being in such a fine state of disintegration, practically every cell is burst and ready to part with its sucrose. The maceration water or dilute juice could with benefit be applied after the first crushing, or as it leaves the crusher rolls.

"To state the results briefly, we find that the disintegrator has enabled us to increase the tonnage approximately 15 per cent., with vibration and breakages in the milling plant much reduced. The sucrose extraction likewise indicates that a substantial improvement has been effected.

"Another innovation at Aguirre is a device termed a detector coil, which operates in front of the disintegrator and positively rejects tramp iron of any size or shape, even down to an ordinary 1½ in. nail.*

"So positive is this simple apparatus that not a single piece of iron was passed through the mill during the entire crop. It supersedes the D.C. magnet used during the 1934 crop".—(*Inter. Sugar Journal*, Vol. XXXVIII, No. 447, p. 114, 1936.)

* *I.S.J.*, 1935, p. 448.

* * *

Utilization of Bagasse.

An interesting patent for the production of artificial manure from waste cellulose material as bagasse, was recently taken out by A. F. Nuske.* It comprises inoculating bagasse under certain conditions first with a decomposing fungus and later with a nitrogen-fixing bacteria, the result after drying being a product stated to be "superior to the known artificial manures".—(*Int. Sugar Jr.*, Vol. XXXVII, No. 442, p. 405, 1935.)

* U.S. Patent, 2,004,706.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Preparation of Guanidine Nitrate from Ammonium Thiocyanate.

All methods which depend upon the reaction

$$2NH_4SCN = H_2S + CN_3H_5.HSCN$$

yield only up to 38.8 per cent. of the guanidine base. A new method depends on the equation :—

$$NH_4SCN + Pb(NO_3)_2 + 2NH_3 =$$
$$PbS + CN_3H_5.HNO_3 + NH_4NO_3$$

The yield is nearly quantitative, and the process can be carried out at a much lower temperature. This method makes it possible to convert ammonium thiocyanate cheaply into the more valuable guanidine, which contains over 40 per cent. nitrogen. It may lower the price of guanidine sufficiently to make it usable as a manure.—(*Angew. Chem.*, Vol. XXVII, p. 409, 1935. Abstr. in *J. Chem. Education*, Vol. XIII, p. 46, 1936.)

* * *

Salt Highways.

Roadways of salt are being sponsored by the International Salt Co., and are constructed under a method discovered by Dr. Cloyd D. Looker, research director of the company, and developed in conjunction with Dr. H. Ries, Professor of Geology, Cornell University. About 100 miles of such salt highways have been laid in various parts of the U.S.A., and after several months' use they have proved to be satisfactory. The roads are built of clay and gravel treated with a rock salt compound, which not only compacts the clay, giving it a concrete effect, but also crystallises in the road surface and retards the evaporation of moisture, keeping the top moist and firm and practically non-skid. The mixture is intended for secondary roads and to provide firm surfacing at a small cost, as its cost per mile is about one-third that of asphalt and one-ninth that of cement necessary for a concrete road.—(*Ind. Bull.*, Arthur D. Little Inc. No. 105, p. 4, 1935. Abstr. in *J. Chem. Education*, Vol. XIII, p. 94, 1936.)

* * *

New Du Pont Fabric.

A new material, making possible the manufacture of untarnishable metallic fabrics, is announced by E. I. du Pont de Nemours and Co., Wilmington, Delaware. It is made of metallized split cellulose film, and is prepared by depositing a non-tarnishable metallic finish on one side of a sheet of cellophane. Two such sheets are then joined together, so that each side is metallic coated, which imparts added strength to the stock. The sheet is then split into narrow yarn widths, which may then be woven into a fabric along with rayon, silk, wool or cotton. This material is the latest contribution of the chemical industry to the textile world. It is claimed that the new fabric will not tarnish or oxidise, thus solving a problem which has always proved difficult in the production of metallic textiles, of which there has been such a great vogue recently. The new material was designed primarily for decorative use, but its adaptation to other purposes has been so satisfactory that it is being employed also in the fashion field.

After many tests, it is found also to have a place in the industrial field. It is adaptable to commercial methods of decorating, such as lithographing, silk screen stencilling, embossing, corrugating, creping and shredding.—(*J. Chem. Education*, Vol. XIII, p. 50, 1936.)

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The Detection of Potassium by a Rapid Microchemical Reaction.

A. Kniga, of the Voronesh Chemical Institute, has found a new microchemical reaction for potassium, by application of the extremely high crystallisation rate of potassium permanganate. As a reagent, a solution of sodium permanganate ($N_aM_nO_4 .3H_2O$) is used. One drop of the potassium salt and one drop of the reagent are sufficient to disclose the presence of potassium by the formation within a short time of easily visible potassium permanganate crystals. The sensitivity of the reaction is 0.04 mg. of potassium, and it is applicable to the following potassium salts: fluoride, chloride, bromide, chlorate, perchlorate, iodate, sulphate, nitrate, nitrite, orthophosphate and chromate. Sodium, magnesium, calcium, strontium, barium, zinc, aluminium, cadmium, nickel, bismuth and copper give no reaction. The presence of dilute acids (hydrochloric, sulphuric and nitric) as well as of alkalies, does not interfere markedly with the reaction.—(*Ind. & Eng. Chem., News Ed.*, Vol. 14, No. 1, p. 5, 1936.)

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Alcohol and Alcohol-Gasoline Blends as Fuels for Automotive Engines.—*A. L. Teodoro.*

Using the following fuels: (1) 95 per cent. alcohol, 99 per cent., gasoline 0.5 per cent., and aniline, 0.5 per cent.; (2) 99.6 per cent. alcohol, 99 per cent., gasoline 0.5 per cent., and aniline, 0.5 per cent.; and (3) straight gasoline, performance tests were carried out using automobile engines. Data are tabulated on fuel and oil consumption per b.h.p. per hour, engine speed, &c., under different conditions of running. No difficulty in starting was found with the alcohol fuels, and engine operation with them was steadier than with gasoline at or near the full capacity, but at low speeds and at very light loads operation with gasoline was a little better than with alcohol fuels. A useful paper for the fuel engineer.—(*Int. Sugar Journal*, Volume XXXVIII, No. 445, p. 37, 1936.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observation is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.)

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
27th February	4	8¼	8	6¾
5th March	4	7½	8	4½
12th March	4	9¾	8	6¾
19th March	4	9	8	6¾
26th March	4	9¾	8	6¾
2nd April	4	10½	8	8¼
9th April	4	10½	8	8¼
(11th *April*, 1935)	5	0	8	9

After a period of weakness the market has shown renewed strength owing mainly to the sudden tension in the European political situation. This was accompanied by a revival of demand from the trade and the lifting of hedges. Orders, according to Gillespie Bros., poured in on refiners who are said to have made sales amounting to 120,000 tons. Visible supplies at 5,829,000 tons as against 7,384,000 tons a year ago reveal a distinct improvement in the statistical position which, however, does not appear at present to count for much. The American market has shown firmness and activity.

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RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	Pence per lb.
26th February	7 5-16
4th March	7 7-16
11th March	7 1-2
18th March	7 1-2
25th March	7 7-16
1st April	7 1-2
8th April	7 7-16
(10th *April*, 1935)	5 9-16

Quotations on the whole have remained steady despite the disturbed political outlook. American consumption fell off as a result of a strike which lasted about six weeks at the Goodyear works in Akron. This has now been settled and American demand is likely to expand in the near future. Stocks in the United Kingdom are declining steadily and as current world production is below consumption, a further improvement in the position of rubber is expected.

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BANANAS. The demand has improved largely as the result of warmer weather. Jamaicas quoted at £16 15*s.* or £1 10*s.* per ton higher, delivered London. Brazilians at £14 10*s.* delivered nearest station are £2 10*s.* higher.

COCOA.—Since last writing the cocoa market has had spells of dullness, followed by little bursts of activity, with cheap second hand sellers offering Accra afloat, even below 23*s.* c.i.f., retiring. It looks as if the political situation will remain a disturbing factor of the market for some time. Accra cocoa is being quoted at 23*s.* 9*d.* c.i.f. and locally $7.50 per fanega is paid for Plantation Cocoa. —(*By Courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*)

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COTTON. The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
28th February	6.04	9.03
6th March	6.12	9.20
13th March	6.30	9.36
20st March	6.34	9.31
27th March	6.44	9.20
3rd April	6.42	—
11th April	6.57	—
(12th *April*, 1935)	6.65	8.35

Trade has been affected by political developments but prices of American have showed remarkable steadiness. About 200 bales of Sea Island from the Leeward Islands have been sold at prices ranging from 15*d.* to 22*d.* according to quality—stains selling at 8*d.*

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COFFEE.—Large supplies have been offered at auction, Costa Rica being the largest contributor. A good demand prevailed. Kenya sold well for good quality lots. Jamaica still very slow of sale. Superior Santos quoted at 38*s.* c.i.f.

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LIME PRODUCTS.—*Lime Juice.*—Very quiet and unchanged for Raw. Concentrated quoted at £7. *Lime Oil.*—Absence of demand. Distilled 22*s.* 6*d.* on the spot. Hand pressed, nominal at 35*s.* per lb.

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GRAPEFRUIT.—Jamaica and Trinidad, standard case, 10*s.* to 13*s.* per case. Palestine, standard case, 64's, 12*s.* to 13*s.* per case; 80's, 15*s.* to 16*s.* per case, and 96's, 17*s.* per case. The Trinidad fruit is reported as of rather nice quality and as selling fairly freely.